



**SUPPORT FOR MATHEMATICS TEACHERS AND STUDENTS IN PREVIOUSLY
DISADVANTAGED CAPE TOWN HIGH SCHOOLS**

By

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Signed

Date

ABSTRACT

A large majority of school leavers in South Africa have limited educational and career opportunities in occupational fields such as medicine, engineering, information technology and scientific research because of poor performance in mathematics and science at Grade12 level. Although various forms of support for mathematics teaching and learning have been introduced by the government and private institutions to overcome some of these challenges and improve performance, South African mathematics performance still remains at the bottom of the rank. Underachievement in mathematics has been particularly recognised as a major problem in schools serving black, coloured and Indian students from historically poor communities – also known as previously disadvantaged communities - in South Africa.

The main purpose of this research was to increase understanding of the specific challenges of mathematics teaching and learning at a selected number of schools in the previously disadvantaged Cape Flats area of Cape Town, and to explore the availability of, access to, and utilisation of support opportunities by the mathematics teachers and students at these schools with the aim of identifying appropriate support programmes for such schools.

Bronfenbrenner's ecological systems theory was used as the theoretical framework for this research. Bronfenbrenner advocated that research investigating human development should involve a field-theoretical approach in which the interaction of process, person, and context are taken into consideration. The underlying rationale for a process-person-context research model is also applicable to organisational development, and is a useful model for understanding how developmental processes (e.g. mathematics teaching and learning) and outcomes (e.g. students' achievement in mathematics) vary as a joint function of the characteristics of not only the school itself but also those of the ecological systems or environment surrounding the school.

The study was conducted using an exploratory sequential mixed method research (MMR) approach. Both qualitative and quantitative data were collected and analysed. This enabled the researcher to conduct an in-depth examination of the varied, detailed and extensive array of information obtained from different sources to provide extensive explanation that portray a holistic picture of the situation at each school. Five schools from two education districts in the Cape Metropole participated in the study. Five curriculum advisers from the eight education districts in the Cape Metropole in which the schools are situated, as well as five

mathematics teachers and heads of departments responsible for mathematics teaching and learning at each of the five schools were interviewed. Twenty Grade 12 mathematics students at each of the five schools completed a survey questionnaire designed to elicit respondents' views on challenges they faced in the teaching and learning of mathematics. This included their views on parental involvement and support. The survey was followed by focus group interviews with twenty Grade 12 mathematics students at each school, thus totalling 100 mathematics student participants.

The findings suggest that although certain current mathematics support initiatives prove to be effective in some ways, various limitations exist in terms of the purpose and objectives of these opportunities. Numerous factors need to be taken into consideration for a mathematics support opportunity to be deemed 'appropriate'. Mathematics support programmes ought to encourage partnerships with mathematics experts, with the main focus on underperforming (*in mathematics*) schools. Further, greater emphasis should be placed on the structural components of the mathematics curriculum, with specific reference to the weighing of practical content and the flexibility of the curriculum to adapt to underperforming students. Mathematics support programmes should prioritise the use of technology in the mathematics classroom as it is currently undervalued, despite the technological advancement in all other areas of our daily living. The study proposes that the Western Cape Education Department's policies regarding mathematics support opportunities should regularly be revised and evaluated by those responsible for policy coordination, strategic people management and education planning, with the aim of keeping individuals at departmental level and at school level responsible and accountable for the implementation of specific tasks. These tasks include the allocation of resources and support from departmental officials. In addition, various methods of communication should be effectively utilised, from management level at the Western Cape Education Department to the school and the community level (parents), with regard to circulating information on any mathematics support opportunities identified and available to mathematics teachers and students.

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DEDICATION

To my Heavenly Father:

I can do all things through Christ which strengtheneth me.

Philippians 4:13 (KJV)

**Great is the Lord, and greatly to be praised; and His greatness is
unsearchable.**

Psalms 145:3 (KJV)

**Nay, in all these things we are more than conquerors through Him that loved
us.**

Romans 8:37 (KJV)

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LIST OF ACRONYMS

ACE	Advanced Certificate in Education
AIMSSEC	African Institute for Mathematical Sciences Schools Enrichment Centre
AMESA	Association of Mathematics Educators of South Africa
ANA	Annual National Assessments
CA	Curriculum Advisor
CAPS	Curriculum Assessment Policy Statement
CDE	Centre for Development and Enterprise
CPUT	Cape Peninsula University of Technology
DBE	Department of Basic Education
DBSA	Development Bank of South Africa
DHET	Department of Higher Education
DOE	Department of Education
EFA	Education For All
ELRC	Education Labour Relations Council
FET	Further Education and Training
GET	General Education and Training
HOD	Head of Department
HSRC	Human Science Research Council
ICT	Information and Communication Technology
IQMS	Integrated Quality and Management Systems
ISP	Individual Service Plan
IT	Information Technology
LOLT	Language of Learning and Teaching
LTSM	Learning and Teaching Support Material
MCA	Mathematics Curriculum Advisor
MIDHub	Mathematics Information and Distribution Hub
MM	Master Maths
MSEP	Mathematics and Science Education Project

MT	Mathematical Thinking
NGO	Non-Governmental Organisation
NPDE	National Professional Diploma in Education
NSI	National Statistical Institute
NSI	National Statistical Institute
OBE	Outcome Based Education
OECD	Economic Co-operation and Development
PATH1995	Partnership for Access to Higher Mathematics
PHE	Policy Handbook of Educators
PMD	Parliamentary Monitoring group
SADTU	South African Democratic Teachers Union
SAHRC	South African Human Rights Commission
SBST	School Based Support Team
SDIP	Service Delivery Improvement Plan
SDIP	Service Delivery Improvement Plan
SDU	Schools Development Unit
SES	Social Economic Status
SMILES	Science and Mathematics Initiative for Students and Educators
SSA	Statistics South Africa
SSIP	Secondary School Improvement Programme
STI	Science, Technology and Innovators
SU	Stellenbosch University
SUNCEP	Stellenbosch University Centre for Pedagogy
TDP	Teacher Development Plan
TIMSS	Trends in International Mathematics and Science Study
UCT	University of Cape Town
UKZN	University of KwaZulu Natal
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCED	Western Cape Education Department
ZPD	Zone of Proximal Development

CHAPTER 1

INTRODUCTION AND OVERVIEW

1.1 INTRODUCTION

Globally, competence in mathematics is generally recognised as a critical skill related to occupational and educational choices, and thus having an impact on the economic development of a country (Tsafe, 2014). According to Tsafe, mathematics is the foundation of scientific and technological knowledge, and it is recognised for its influence in formulating, interpreting and solving problems in fields as diverse as engineering, economics and communication.

Numeracy or mathematical knowledge is seen as a crucial skill (Ofsted, 2012; Vorderman Porkess, Budd, Dunne & Rahman-Hart, 2011). Against this background, an increasing requirement exists in the range of life skills fundamental to manage aspects such as personal finance (e.g. choosing a mortgage, budgeting, phone contracts) and data-handling (All Party Parliamentary Group on Financial Education, 2011; Vorderman et al., 2011; Norris, 2012).

South Africa differs from many other countries in several respects: Included here are extreme levels of inequality and the recent apartheid¹ history that systematically disempowered the majority of South Africans. Fleisch (2008) noted that over 60% of South African children live in poverty and that South Africa has long been one of the most unequal countries in the world. With regards to educational outcomes, South African students rank in the lower half in comparison to other low and middle-income countries that participate in cross-national assessments of educational achievement (Spaull, 2013). The majority of students have limited educational and career opportunities in occupational fields such as medicine, engineering, information technology and scientific research because of the poor performance in mathematics and science at Grade 12 level (Kafata & Mbetwa, 2016).

According to Chipangura (2013), in 2012, only a small number of students (less than 20 000 of the roughly half-a-million who wrote the National Senior Certificate examination) got the levels of results for Grade 12 mathematics that would allow them to cope with university level mathematics courses required for degrees such as engineering or actuarial science. This

Apartheid: In South Africa, a policy or system of segregation or discrimination on grounds of race

apparent challenge for students to achieve satisfactory results in mathematics is one of the reasons that most Grade 12 mathematics students opt for mathematical literacy instead of pure mathematics. Pure mathematics involves abstract problem solving and reasoning and content far more advanced than mathematical literacy. Mathematical literacy focuses on skills rather than content, and is driven by day to day life-related applications of mathematics. Mathematical literacy, therefore, does not equip students to pursue careers such as engineering, architecture, construction and business studies and it is only accepted as an admittance subject for some qualifications at universities and Further Education and Training (FET) colleges (Master Maths, 2015).

According to the Department of Basic Education (DBE, 2017), the proportion of students enrolling at high school (Grades 8 to 12) for mathematics and science at the FET phase (i.e. Grades 10 to 12) has declined. Other DBE reports indicate a 17% decline in the number of candidates who wrote the National Senior Certificate (NSC) mathematics examination between 2009 and 2013 (from about 290 400 to 241 400). A recent 2019 report, conducted by Statistics South Africa (SSA), indicate a substantial decrease of 5568 students enrolling for the mathematics NSC exams between the 2017 and 2018 academic year. More so, in 2018, 58% of students writing the NSC mathematics examinations achieved 30%, and a mere 37.1% achieved 40% (DBE, 2019). At the same time, the number of candidates writing mathematical literacy rose sharply to 58% of the 2013 cohort. In 2014 the number of students who wrote the NCS mathematics examinations, as well as the number getting a good pass – which provides a gateway into mathematics-related tertiary study – also decreased (Campbell & Prew, 2014). The Science, Technology and Innovators (STI) indicators report based on the analysis of the National Statistical Institute (NSI) performance during the period between 1996 and 2016 indicated that the percentage of Grade 12 students who passed mathematics with at least 50% remains low. In addition, the proportion of Grade 12 female students passing mathematics with at least 60% has been declining from 2008 to 2016 (Department of Science and Technology, 2016).

One of the basic assumptions, as stated in the South African national policy documents for Curriculum 2005, is that all students can learn mathematics and succeed within the boundaries of attaining important goals such as equity, access, redress and personal empowerment (Department of Education, 1996, 1997). However, the reality is that one in every four schools in South Africa does not offer pure mathematics in Grades 10, 11 and 12

(Phakathi, 2015). In June 2015, the Department of Basic Education revealed in parliament that 75.7% of public ordinary schools in South Africa offer pure mathematics from Grade 10 to Grade 12. According to the Minister of Basic Education, Angie Motsekga, in a parliamentary response DBE, “non-availability of qualified, competent teachers of FET phase mathematics” is one of the reasons some schools do not offer the subject. (Pillay, 2015). In a bid to address these shortcomings, in 2016, the Department of Basic Education (DBE) partnered with TEACH South Africa, to recruit new mathematics graduates from university to teach in South African schools in where there was a shortage of mathematics teachers. One of the other reasons that some schools deliberately drop pure mathematics and offer only the much easier mathematical literacy is to create an impression of improved Grade 12 results (Nkosi, 2014).

Bussi and Pareliussen (2015) ranked South Africa second-to-last in the performance in mathematics and science according to a report of the Organisation for Economic Co-operation and Development (OECD, 2012). The OECD findings, based on the mathematics test scores of 15-year-olds from 76 countries, show that South Africa ranked 75th globally – beating only Ghana. These statistics depict an education system that is facing challenges in increasing its output of high school leavers with university-entrance mathematics passes and thus limited career choices in a technologically growing society.

1.2 CONTRIBUTING FACTORS TO POOR PERFORMANCE IN MATHEMATICS

1.2.1 The apartheid education system

Underachievement in mathematics among South African students is particularly recognised as a major problem in schools serving disadvantaged communities (Mkhabela, 2004). The explanation of the concept “disadvantaged” is important in facilitating an understanding of the past and present education system in South Africa. According to Gordon (2004), the term “disadvantaged students” refers to a group of students with common characteristics of coming from populations with low social status, low educational achievement, tenuous or no employment, limited participation in community or organisations and limited ready potential for upward mobility. Schools in previously disadvantaged communities formed part of apartheid policies where the emphasis was on racial segregation, social and ethnic differentiation, and exclusion from equal and quality education provided to their white counterparts (Sedibe, 2011).

Wilkinson and Pickett (2009) highlight the impact of apartheid policies in South Africa in terms of the socio-economic extremes within the country, with one of the largest differences in the world between rich and poor. Related to this has been one of the largest differences in mathematical performance between students in wealthier and poorer quintiles of schools (Reddy, 2016). Schools in Quintile 1 are the schools in each province with students from the poorest 20% of communities. Quintile 2 schools cater for the next poorest 20% of schools, and so on. Quintile 5 schools are those schools that cater for the least poor 20% of students. The quintile system inversely determines the amount of funding that an individual school receives and was an initiative of the government in post-apartheid South Africa to redress and redistribute resources in education (Kanjee & Chutgar, 2009). Despite the increased funding provided to those schools in the lowest quintiles, inequalities between schools persist to the extent that the backlogs in apartheid education requires a much greater investment than has been achieved through existing levels of budgetary allocation. The last publication of The School Monitoring Survey Report of the Department of Basic Education (2013) indicated that students from impoverished communities are provided with education of poor quality, attend schools which are under-resourced and where teaching and learning is poorly monitored, a situation reported with schools in Quintiles 1, 2 and 3 (Kanjee & Chutgar, 2009).

The unequal education policies of the apartheid era also resulted in the shortage of appropriately qualified mathematics teachers. In 2005, the Education For All (EFA) initiative found that although 85% of mathematics teachers in South Africa were professionally qualified, only 50% were appropriately qualified in mathematics (EFA, 2005). A case in study: A high school in King William's town in the Eastern Cape, South Africa, Simzamile Secondary School, revealed that the school has only one mathematics teacher for all grades (grades 8 to 12). Furthermore, two other high schools in the same province, Umzuvukile and Dulabuhle Secondary schools have no mathematics teachers at all (Gilili, 2018). From my research it should be noted that there is indeed a dearth of research in verifying and confirming the statistics surrounding qualified mathematics teachers in South Africa.

The Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) survey found that "... in South Africa teachers with better subject knowledge in mathematics and reading were more commonly deployed to urban and better-resourced schools" (Education For All (EFA), 2015:249). According to a press release by Professor Jansen Snyman, from the South African Institute of Race Relations (2013), more than 84

schools countrywide did not offer mathematics in the Further Education and Training (FET) phase because there were simply not enough suitably qualified mathematics teachers to teach those classes. Williams (2014) attributes this situation to inadequate apartheid-era teacher training programs and ineffective post-apartheid in-service training. One implication of the above statistics is that many mathematics teachers might not have the necessary knowledge and skills to assist in remediation of students who experience challenges in mathematics. In addition, mathematics teachers often do not have the skills to reinforce or develop early basic foundation skills among foundation (Grades R to 3), intermediate (Grades 4 to 6) and senior phase (Grades 7 to 9) students.

1.2.2 Teaching and learning mathematics in a second or third language

Teachers in many South African schools, particularly those in previously disadvantaged schools, face the additional challenge of teaching mathematics to students in their second, or even third, language. From Grade 4 the default language of learning and teaching (LOLT) is either English or Afrikaans, whereas the majority of the South African population has one of the other nine indigenous languages as their home language. For most schools in previously disadvantaged areas in South Africa, English is a second language for the majority of students. This situation affects both the teaching in a second language and students' learning in a second language. Mother tongue instruction is important for the clear formulation of mathematical concepts, as all ideas are communicated between the teacher and the learner, either through oral or written material (Cocking & Mestre, 1989, cited in Kaphesi (2004). It is difficult for students whose first language is not English to understand mathematical concepts taught to them in that language (Howie, 2002; Makgato & Mji, 2006: 261). South African children who wrote the TIMSS (Trends in International Mathematics and Science Study) 2011 test in their second language performed rather poorly. According to Bloch (2013), this is partly because they did not write the test in their home language. All the children from developed countries wrote the test in their home language.

1.2.3. Trends in Mathematics and Science Study (TIMSS)

Based on the TIMSS results for 1995, 1999 and 2002, Reddy (2006) categorised learner performance scores according to the previously racially segregated schools and showed, not surprisingly, that despite their levels of resourcing, the former white (ex-model C) schools performed only at the international average, whilst the former so-called African schools performed at half the average of the white schools. The TIMSS 2015 report confirms this finding, as it projects similar results. In TIMSS 2015, the mathematics scores and standard errors for the different school types are: public no-fee schools 341 (3.3) points, public fee-paying schools 423 (10.0) and independent schools 477 (11.5). The TIMSS mathematics scores (points) can be interpreted as follows:

“TIMSS defines four categories of benchmarks, namely: scores between 400 and 475 points are classified as achievement at a low level, scores between 475 and 550 points as achievement at an intermediate level, scores from 550 to 625 points as achievement at a high level and scores above 625 points as achievement at an advanced level.” (Reddy, Visser, Winnaar, Arends, Juan & Prinsloo, 2016). These results indicate a difference of 82 points between the South African TIMSS 2015 participating public no-fee schools in comparison to public fee-paying schools. Furthermore, an increase of 136 points is observed in comparison to independent schools. Reddy, Visser, et al. (2016) explains that the physical conditions and the context of the schools are often contributing factors to low performance in mathematics, as is the case with the public-no fee schools in the TIMSS 2015 study.

Vithal (2012) asserts that African schooling has come under intense scrutiny, has had a myriad of interventions and is being researched for its lack of effectiveness. White schooling, however, has remained outside the research gaze and has not been interrogated, for example, for its failure to exceed international averages given their disproportionate share of considerable resources and other advantages.

TIMSS (2011) revealed that 95% of students were negatively affected by inadequate resources for mathematics instruction. Results from TIMSS 2006-2007 indicate that students in schools that are well-resourced with mathematics-specific resources such as computers and computer software, calculators and mathematics instructional materials generally have a higher achievement than those in schools where shortages of resources affect the capacity to implement the curriculum (Caygill, Lang & Cowles, 2010). Studies have shown that resources

are crucial for improving results, perhaps even more so in developing countries than in economically developed countries where adequate school structures and material resources can be taken for granted (Lay, 2016; Lee & Zuze, 2011; Nel, 2016).

1.3 INITIATIVES TO ADDRESS CHALLENGES FOR MATHEMATICS TEACHERS AND STUDENTS

1.3.1 Teacher professional development

Zuzovsky (2013) asserts that teachers' qualifications comprise the following: teachers' scores on tests and examinations; their years of experience; the extent of their preparation in subject matter and in pedagogy; content knowledge they hold in their area of expertise; and their ongoing professional development.

Some studies show that mathematics teachers need support and interventions. For example, Siyepu (2013: 10) argues that mathematics teachers' competencies may be improved by means of in-service courses. This view is supported by Makgato & Mji (2006: 254), who state that in 2001 the national Department of Education estimated that 8 000 mathematics teachers needed in-service training. In the same year, the Department introduced the Dinaledi Programme to provide support in the form of physical resources and equipping teachers with the necessary pedagogical and content knowledge and skills to improve the science and mathematics results within selected schools (EFA, 2010).

Similar support opportunities to improve mathematics teaching were introduced by others. For instance, in 2009 the University of Stellenbosch established the Science and Mathematics Initiative for Students and Educators (SMILES) schools' partnership project. University-based facilitators embarked on class visits to five historically disadvantaged high schools and 10 primary schools in the Cape Winelands district, with the objective of identifying teachers' needs, initiating co-teaching and offering professional support (Ndlovu, 2011).

Several non-profit organisations in the private sector also offer professional development courses for teachers, such as the AIMS Schools Enrichment Centre (AIMSSEC) which offers mathematics subject leader training courses to teachers from schools in disadvantaged communities to enable them to train other teachers. In 2015, the South African Department of Basic Education introduced the 1+4 Teacher Development Plan (TDP) for mathematics

teachers. According to the TDP, mathematics teachers are to be exposed to 30 days of training, development and support on a weekly basis, followed by a post-training test.

1.3.2 Educational support for mathematics students

Support is also given to mathematics students. According to Baker, Akiba, LeTendre and Wiseman (2001), more than 75% of Grade 8 students in South Africa received supplementary tuition at the time. Furthermore, of the three forms of supplementary tuition (i.e. private tuition, vacation school and revision of model or former examination question papers), revision of examination papers was preferred most (about 83%) followed by private tuition at 81% and lastly vacation school. More recent results show that on average, mathematics students spend about 1.67 hours per week on supplementary tuition (Coetzee, 2009). According to the Centre for Development and Enterprise (2013), the exact number of mathematics students taking supplementary tuition is unknown. However, from a study the Centre for Development and Enterprise (2013) conducted at a few selected high schools in Johannesburg (South Africa), the results indicated that between 25% and 50% of the mathematics teacher respondents acknowledged that they have provided extra mathematics lessons. Other recent support opportunities include the SUNCEP (Stellenbosch University Centre for Pedagogy) in the Faculty of Education at Stellenbosch University (SU) that provides supplementary tuition in mathematics to students from all grades during the June school holidays. The tutors are teachers and curriculum advisors in teaching positions at the provincial education department districts relevant to the areas where the tutoring takes place (Ndlovu, 2011). Many students make use of supplementary tuition programmes offered privately by non-profit organisations, mathematics teachers and specialist extra mathematics tuition franchise companies such as Master Maths, Kip McGrath and Kumon, extra mathematics schools such as Maths Tutor, extra mathematics revision programmes offered by certain universities during the school holidays; and specialist education support services such as Brombacher and Associates (Centre for Development and Enterprise, 2013). However, some of these supplementary tuition programmes are costly and therefore generally accessible only to those who can afford them (Reddy, 2005).

1.4 RESEARCH PROBLEM

Given the challenges in mathematics teaching and learning in South Africa, it is evident that there is a need for support for both mathematics teachers and students in South African

schools, and particularly those in previously disadvantaged communities (Makgato & Mji, 2006). These support opportunities may help to improve teachers' proficiency and students' performance in mathematics.

Several studies have been conducted into the various support programmes that have been introduced in South Africa (Reddy, 2006; Coetzee, 2008; Ndlovu, 2011; Zenex Foundation, 2012; Centre for Development and Enterprise, 2013). For example, Coetzee (2008) explored and evaluated the prevalence of supplementary tuition in the teaching and learning of mathematics and/or mathematical literacy in a number of high performing schools of the East London district in the Eastern Cape. The study found that students sought supplementary tuition irrespective of the high-performing schools they attended, which employed in their opinion well-qualified and committed teachers. A reported lack of time points to one of the factors accounting for the need of supplementary tuition. Other reported factors include the need for more individual attention in the subject, possibly to overcome misconceptions. Furthermore, the study showed that most students regarded mathematics as important for their future careers and therefore they perceived a need to improve their performance in the subject. Of the 76 respondents (21% of the total) who indicated that they received supplementary tuition in 2007, only 11 of the 159 mathematical literacy students (6%) received supplementary tuition, compared to 65 of the 129 Mathematics students (34%). Of the students who did not receive private tuition, 56 (21%) indicated that they could not afford private tuition.

Other studies include that of Machaba (2013), which focused on support for mathematics teachers, initiated by the Department of Basic Education's School Based Support Teams (SBST). The study was conducted at 5 primary schools in disadvantaged areas in the Tshwane South District, South Africa. The sample consisted of five Grade 3 classes, one at each school. The study established that almost all the teachers were using various non-standardised methods to identify children who experienced problems in mathematics. Furthermore, teachers who participated in this study were not able to understand the complexity of the reasons that lead to children experiencing difficulties in mathematics. They therefore failed to respond positively to questions or activities. Machaba concludes that these teachers themselves were not adequately trained to identify children who experience difficulties in mathematics.

Most of the studies mentioned focus on a single support opportunity, such as supplementary tuition, or programmes that are restricted to a select group of schools, such as the Dinaledi and SMILE initiatives.

As shown in the preceding discussions, research on the support provided for mathematics teachers and students consists of fragmented efforts focusing on distinct entities. These efforts fail to provide a comprehensive and a systematic analysis of the support given to the teachers and students. There is thus a need for a study which investigates interactions and collaborations by various stakeholders (national and provincial departments of education, education district offices and their officials, school management, school governing bodies, teachers, parents, students, peers and external providers).

1.5 PURPOSE OF THE STUDY

The purpose of this study was to:

1.5.1 Gain deeper insights into understanding the challenges in Grades 8 to 12 mathematics teaching and learning at selected schools in disadvantaged communities.

1.5.2 Identify the support available for Grades 8 to 12 mathematics teachers and students.

1.5.3 Identify the support opportunities that the Grades 8 to 12 teachers and students at the selected schools have utilised, and experienced.

1.5.4 Identify the strengths and limitations of the available support opportunities.

1.6 THE RESEARCH QUESTIONS

1. What is the availability of, access to, and utilisation of support opportunities by the mathematics teachers and students at the selected schools?
2. What mathematics support opportunities would be most appropriate for mathematics teachers and students at these schools?

1.7 RATIONALE FOR THE STUDY

This study aims to draw attention to the challenges experienced by Grade 8 to 12 mathematics teachers and students at the five selected previously disadvantaged schools. Consequently, these challenges could be addressed comprehensively by all stakeholders (national and

provincial departments of education, education district offices and their officials, school management, school governing bodies, teachers, parents, students, peers and external providers) in search of finding suitable mathematics support opportunities for teachers and students in similar circumstances. This could lead to improved achievement in mathematics at disadvantaged high schools, with the expectancy of better mathematics education in general. Consequently, it will be beneficial to the country as a whole if the results can demonstrate the most appropriate support programmes and interventions to improve performance in mathematics.

1.8 RESEARCH METHODOLOGY FOR THE STUDY

This study employed a case study research methodology, with five participating schools purposively selected from the 30 high schools in the Cape Flats area on the basis of the common socio-economic background of the areas in which they are located. Purposive sampling, which requires identifying the participants with the relevant characteristics required for the study, was used in selecting four mathematics teachers and the Head of Department (HOD) from each of the five schools in each phase, two from the GET Phase (Grades 8 and 9), two from the FET Phase (Grades 10 to 12), and one Head of Department. They were selected on the basis that they teach mathematics at these schools, have spent several years in the positions they hold, and possibly having a broader understanding of the situation at their schools. One-on-one interviews were conducted at the respective schools with the mathematics teachers and HOD, with the aim of determining the challenges they face in teaching mathematics; and the type of mathematics support provided to them by the school, the Western Cape Education Department (WCED) and external providers. A survey questionnaire was administered to 20 Grade 12 mathematics students at each school to establish the challenges they face in mathematics teaching and learning. The survey questionnaire included identifying factors that affect the availability, access to and utilisation of support in mathematics at the school and from their parents. Focus group interviews were held with two groups of Grade 12 students who were doing pure mathematics at each school. Each group of student respondents consisted of 10 students.

One-on-one interviews were conducted with five officials from the Western Cape Education Department (WCED) responsible for providing support to mathematics teachers and students.

The transcripts resulting from the interviews with teachers and officials and the focus group interviews with students formed the substantive body of qualitative data for analysis. This was supported by quantitative data from the survey questionnaire administered to the students. The process produced rich and sufficiently detailed results in respect of the research questions: (1) What is the availability of, access to, and utilisation of support opportunities by the mathematics teachers and students at the selected schools? and (2) What mathematics support opportunities would be most appropriate for mathematics teachers and students at these schools? The quality of the study was further enhanced by ensuring the reliability, validity and trustworthiness of the results. The methodology is presented in more detail in Chapter 4.

1.9 RESEARCH ETHICS

Participants were provided with a consent form to sign approving their participation in the research (see Appendix D). Prior to the commencement of the research, participants were informed of the purpose and procedures of the study; they were assured that their participation was voluntary, confidential and anonymous; that they could withdraw at any stage; and that pseudonyms would be used. Participants were guaranteed that the researcher would adhere to ethical procedures and report on the research findings in a professional and accountable manner. Ethical clearance was obtained from the Research Ethics Committee of the institution at which the researcher was registered for her doctoral studies (see Appendix B). Permission to conduct the study was obtained from the Western Cape Department of Education (WCED), under which the schools from which teachers and students were selected, resort (see Appendix A). The ethical guidelines adhered to are outlined in Chapter 4.

1.10 STRUCTURE OF THE STUDY

This report of the study is structured in the following way:

Chapter 1 presents the background of the study and broader context to the formulation of the research problem and research questions. The purpose of the study is outlined, and the rationale for the investigation as a whole is explained. A brief discussion of research design and methodology follows. The chapter concludes with an outline of the structure of the dissertation.

Chapter 2 presents an outline of the theoretical framework of the study. The framework that guided this research is Bronfenbrenner's ecological systems theory, which is based on his earliest writings on the theory. Bronfenbrenner recognised that children live and grow within the context of family, society, and culture, and that it is important to understand how each context influences the other in the development of the child. The chapter also explains Bronfenbrenner's four nested systems of child development and provides a critique of Bronfenbrenner's theory.

Chapter 3 presents the literature review that focuses on factors that could have an impact on the teaching and learning of mathematics in disadvantaged schools and support opportunities for mathematics teachers and students. The review explores international and national studies on reasons underlying academic achievement in mathematics in the context of underprivileged schools. These include studies on the socio-economic background of students, parental involvement, teacher competencies and qualifications, and availability of resources.

Chapter 4 outlines the methodology and research approach. It focuses on the case study; the selection of particular schools in the Cape Flats area, how the empirical investigation was undertaken, as well as justification for the design and methods used. The approach to data analysis is discussed, as well as issues of ethical consideration, validity and reliability.

Chapter 5 provides empirical evidence derived from in-depth individual and focus group interviews with mathematics teachers, students and officials from WCED, as well as from a survey administered to Grade 12 mathematics students. Three forms of data were used to inform the findings of this study: data obtained from individual interviews with mathematics teachers and curriculum advisors and from focus group interviews with mathematics students; data from the survey conducted with Grade 12 students; and document analyses of the support policies obtained by the relevant departments of education and external providers.

In analysing and presenting the data, two broad themes that guided the data collection were employed: the challenges that influence achievement in mathematics in these schools, and support opportunities for mathematics teachers and students provided by the public and private sectors.

Chapter 6, which is the final part of the report, presents an interpretation of and conclusions drawn from the research results. This chapter highlights the key findings in terms of the research questions, research problem and purpose. The chapter provides recommendations to address challenges that influence achievement in mathematics, as well as for further research in the field of mathematics support provided to stakeholders at various levels of the ecosystems (mathematics teachers, students and parents). Reference is also made of the need to review education policies to accommodate stakeholders' mathematical needs in order to achieve success in the teaching and learning of mathematics at high schools in disadvantaged communities.

CHAPTER 2

THEORETICAL FRAMEWORK

2.1 INTRODUCTION

The primary purpose of this study is to increase understanding of the specific challenges of mathematics teaching and learning at a selected number of schools in the Cape Flats area of Cape Town, and to identify availability of, access to and teacher and student utilisation of support opportunities provided by the relevant departments of education and private providers.

In particular, the purpose of this study was to:

- Gain deeper insights into the understanding of the challenges in Grades 8 to 12 mathematics teaching and learning at selected schools in disadvantaged communities.
- Identify the support available for Grades 8 to 12 mathematics teachers and students.
- Identify the support opportunities that the Grades 8 to 12 teachers and students at the selected schools have experienced, and utilised.
- Identify the strengths and limitations of the available support opportunities.

Literature has identified several challenges in mathematics education at the secondary school level. The review of a range of theories that attempt to explain these challenges indicates that most theories focus on one or two-dimensional aspects of such challenges. For instance, Vygotsky, in his Zone of Proximal Development (ZPD), focuses mainly on intrinsic factors such as the student's potential in the development of mathematical concepts (Vygotsky, 1978: 86). In essence, Vygotsky emphasises the difference between what a student can do without help and what a student can do with help. Although Vygotsky's ZPD presupposes interaction, referring to socially determined conditions for learning, it does not specify the nature of such interaction.

Glaserfeld's (1992) radical constructivism theory suggests an almost opposite perspective to Vygotsky's ZPD, focussing on subjective factors while disregarding societal influence and interactions. Critical theory, on the other hand, which is associated with the Frankfurt School (*circa* 1920), adopts a Marxist theoretical perspective and focuses on the socio-cultural and historical transformation of society (Crotty, 1998). Skovsmose (1994) named this critical theoretical perspective *mathemacy*: using mathematics as a socio-political tool to organise

and reorganise interpretations of social institutions, traditions and proposals for political reform. Although the above theories highlight important perspectives on the teaching and learning of mathematics education, they fail to take into consideration a comprehensive understanding of a broader range of interconnected environments and stakeholders that influence mathematics teaching and learning.

2.2 SIGNIFICANCE OF A THEORETICAL FRAMEWORK

The theoretical framework is the foundation from which all knowledge is constructed (metaphorically and literally) for a research study (Grant, 2014). It serves as the structure and support for the rationale for the study, the problem statement, purpose, significance, and the research questions. The theoretical framework provides a grounding base, or an anchor for the literature review, and most importantly, the methods and analysis (Grant and Osonloo, 2014). Kerlinger (1973: 9) defines theory as ‘a set of interrelated constructs or concepts, definitions, and propositions that present a systematic view of phenomena by specifying relations among variables, with a purpose of explaining and predicting the phenomena’. Cohen, Manion & Morrison (2007) add that ‘concepts enable us to impose some sort of meaning of the world; through them reality is given sense, order and coherence. They are the means by which we are able to come to terms with our experience’. According to Maxwell (2012), the main thing to keep in mind is the need for integration of these components with one another, and with one’s goals and research questions.

Furthermore, a researcher needs to select a theoretical platform or specific concepts within a theory that will inform the research. Theory has an important role to play in developmental and family studies, and it is necessary to apply it correctly in research. Failure to apply the most appropriate theoretical framework means that it has not been tested appropriately; data apparently supporting the theory do no such thing if the theory has been incorrectly described, and, by the same token, a misrepresented theory is impervious to attack from non-supportive data (Tudge, Mokrova, Hatfield & Karnik, 2009).

Subsequent to exploring various theories, the conclusion was reached that Bronfenbrenner’s ecological systems theory would be most useful to frame and locate this study within a comprehensive and integrated context. The reasons for this will become apparent below. The theoretical framework for the research is presented as follows:

- Section 2.3 is an overview of Bronfenbrenner's ecological systems theory, which culminates in a comprehensive theoretical framework relevant to this study.
- Section 2.4 provides an elaboration of Bronfenbrenner's four nested systems and a review of empirical studies undertaken that are underpinned by Bronfenbrenner's ecological systems theory.
- Section 2.5 consists of an outline and exploration of critique of Bronfenbrenner's theory.
- The chapter concludes with a visual presentation that places this study within a clear and well-constructed framework which, according to Strayhorn (2010) and Bourdieu's (1977) concept of cultural capital, allows this study to be theoreticalised with similar studies and not be regarded as a stand-alone study.

2.3 BRONFENBRENNER'S ECOLOGICAL SYSTEMS THEORY

The theoretical framework that guides this research is based on Bronfenbrenner's ecological systems theory, which is based on the earliest of his writings on this theory. This framework was used primarily because Bronfenbrenner recognised that children live and grow within a context of family, society and culture, and that it was important to understand how each context influences the other in the development of the child. According to Bronfenbrenner (2005, 1995, 1989), account should be taken of all aspects and interrelationships so that we can have a more comprehensive understanding of how these contexts operate, thus leading to a better understanding of the development of the child.

Bronfenbrenner argued that research investigating human development should involve a field-theoretical approach in which the interaction of processes, person, and context are taken into consideration. Such research would focus on how developmental processes and outcomes vary as a joint function of the characteristics of the person as well as the environment, and their interactions over the course of time (Bronfenbrenner, 2002, 1989). The underlying rationale for a process-person-context research model is applicable to organisational development as well and is a useful model for understanding how developmental processes (e.g. teaching and learning) and outcomes (e.g. students' achievement) vary as a joint function of the characteristics of not only the school itself but also those of the ecological systems or environment surrounding the school. Bronfenbrenner built upon the work of Lewin (1935), who is credited as one of the first theorists to recognise the importance of interaction between the person and environment.

Lewin's (1935) classical field theory behaviour formula is as follows: $B = f(PE)$, where behaviour (B) is the result (f) of interaction between person (P) and environment (E) (Bronfenbrenner, 2002: 223;1989). In a book by Saarinen, Ruoppila and Korhonen, (1994: 90), the same concept is presented in the following way: underlining the meaning of interaction is an understanding that an individual's behaviour is a consequence of the interaction between person and environment. It is the question of an influence that is effective in both ways: person influences environment and environment influences person.

Bronfenbrenner (2002: 223-224; 1989: 189-193) adapted Lewin's formula into the formula of development in the following way: $D = f(PE)$, where development (D) is the result (f) of interaction between (P) person and (E) environment. Bronfenbrenner's bio-ecological study also builds upon and enhances Erikson's research developed in 1902. Both psychologists agree that early experiences and family relationships are crucial for conscious and unconscious identity development. Erikson's eight stages of development are characterised by a different psychological crisis, which must be resolved to allow the individual to move to the next stage and successfully negotiate the changing environment from the microsystem to the macrosystem (Wilson, 2013).

2.4 BRONFENBRENNER'S FOUR NESTED SYSTEMS

Bronfenbrenner identified four nested systems within which the child development occurs. Fundamental to the four nested systems is their interconnectedness Bronfenbrenner (1979) argues that what happens between these systems can be as influential to development as what happens within them. Figure 2.1 presents a diagrammatic view of the four nested systems.

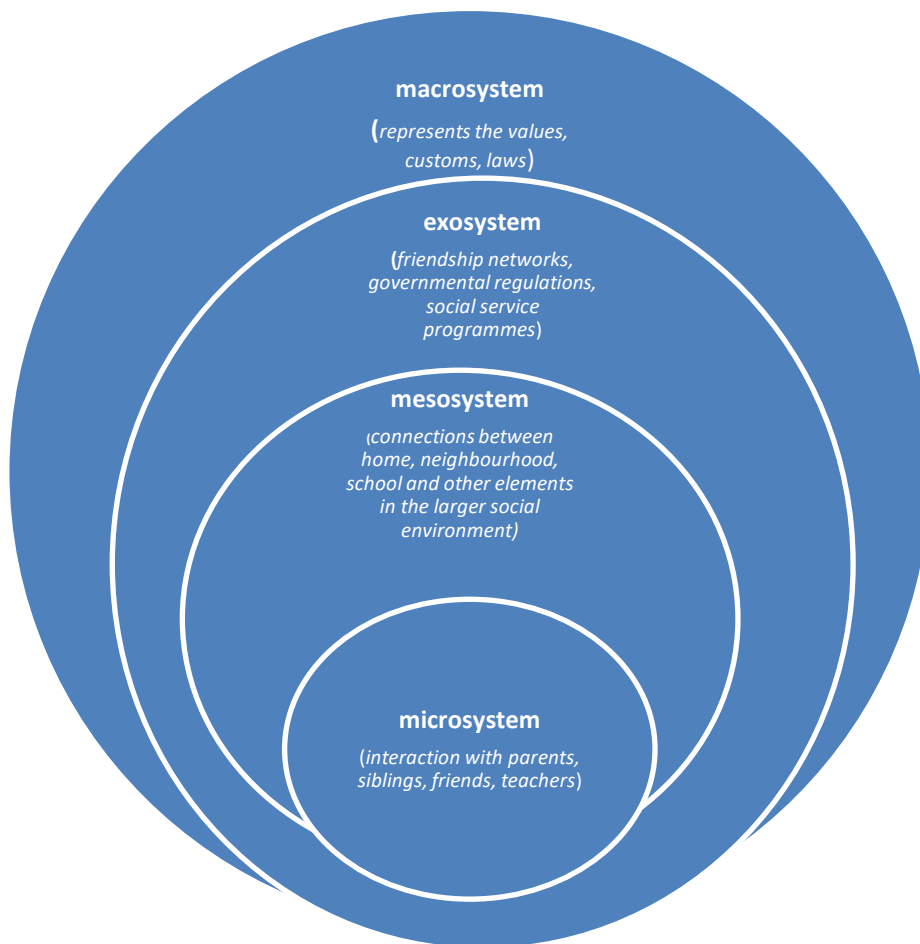


Figure 2.1: Bronfenbrenner's four nested systems (Adapted from Berk & Roberts, 2009)

The *microsystem*, or inner layer, represents the direct relationships and interactions children have with people in their immediate environment (parents, siblings, friends, teachers, etc.). This occurs in any environment, such as home, school, or peer group, in which the developing person spends a lot of time engaging in activities and interactions.

The *mesosystem* represents the connections between home, neighbourhood, school, day care, and other elements in the larger social environment. As people spend more time in more than one microsystem, there are connections between more than one microsystem.

The *exosystem* represents even larger social settings and networks. Extended family networks, friendship networks, governmental regulations, social service programmes, and even workplace rules regarding family leave and flexible hours are examples of elements in the larger social environment that have influences on child development.

The broadest level, the *macrosystem*, represents the values, customs, laws, and resources of the culture at large.

This study focuses on the challenges and support opportunities in mathematics education at the micro-, meso- and exosystemic levels of Bronfenbrenner's ecological systems theory. The

study investigated how home, school and broader organisational factors interact to create challenges in mathematics education. Furthermore, the study reflects on the type of support given to mathematics students within the school and home environments to provide a clearer picture on the nature of the interactions between these systems.

Bronfenbrenner's ecological systems theory is the most appropriate for this study, as it provides a framework for a comprehensive analysis of the interactions between the various systems that are significant for creating challenges and offering support and intervention in mathematics teaching and learning. This theory enabled the study to investigate how different organisms of the ecosystem interact and influence one another. In particular, the study sought to highlight the influence of a number of ecosystemic support levels on the development of teachers and students, as well as the connections among the different spheres of this system.

At the microsystemic level, this study examines parental involvement in and support of their children's mathematics education. An investigation is made into the type of involvement and support parents provide. Campbell and Mandel (1990) divide parental influence into four elements: parental pressure, psychological support, parental help and parental monitoring. Furthermore, Cao, Bishop and Forgasz (2006) distinguish between direct and indirect parental influence. They argue that direct parental influence, such as helping children with difficulties they experience with mathematics, has a less important impact on students' mathematics performance. Indirect parental influence such as parental encouragement, parental expectation and parents' attitudes towards mathematics have been identified as having a significant impact on students' attitudes towards, and consequently achievement in mathematics. Ing (2013), for example, demonstrates that high levels of perceived parental practices such as encouragement and communication of positive ability expectations influence students' mathematical achievement. This study included, but was not limited to, the factors mentioned by Campbell and Mandel (1990) and Cao et al. (2006).

At the mesosystemic level, the study explored the challenges experienced by both the mathematics students and teachers with regard to the identified mathematics support received. A comprehensive view is provided within the context of the school (teaching and learning of mathematics) and the broader community (the relevant education departments).

Schoenfeld (1985) states that mathematics teachers' beliefs can be thought of as an individual's perspective on how one engages in mathematical tasks and pedagogical practices.

Furthermore, teachers' beliefs about the difficulty or ease of mathematics also impact students' motivation and achievement in mathematics. Wentzel (2002) demonstrates how teachers' expectations of students' abilities predicted their levels of interest. Furthermore, perceived teacher affective support has been shown to correlate positively with student interest and achievement in mathematics (Sakiz, Pape & Hoy, 2012).

At the exosystemic level, the focus is on the support opportunities and intervention programmes initiated by the Department of Basic Education, Western Cape Department of Education and external agencies for mathematics teaching and learning to the schools that participated in this study.

The study did not focus on the macrosystemic level. Although of interest, the scope of this study did not allow for extensive investigation at that level. Furthermore, Bronfenbrenner never implied that every aspect had to be included within a study.

Bronfenbrenner's theory has become influential in studies of psychology and human development, education, family studies, and economics. Among the wide variety of proponents of this theory are several scholars in the field of Child and Youth care practices (Ferguson, Pence & Denholm, 1993; White, 2007) and research (Pence, 1988; Brendtro, 2006). Ferguson and his colleagues developed the onion model of Child and Youth care practices based on Bronfenbrenner's theory, in which the 'interacting ecological systems were depicted as layers of an onion, with each layer representing the various systems within the child's ecology such as the family, community, and culture' (Derksen, 2010: 332).

A study conducted by the Behaviour Management Review Group (Powell, 2004) aimed at investigating correlations between affective factors and learning behaviours across English and Mathematics. The findings were consistent with the view that learning behaviour develops from the interaction of the individual with contextual and social factors. Learning behaviour in school contexts thus has affective (feeling), cognitive (thinking) and social (participating) components. All these relationships are in turn influenced by the individual's interaction with cultural and social components of 'out of school' influences, such as the family, outside agencies, policies, and community, etc.

McDougall, DeWit, King, Miller and Killip (2004); Butera (2005) and Hossain (2001) also drew on Bronfenbrenner's ecological systems theory from the 1990s to describe bio-ecological

perspective as one involving the interplay of personal characteristics, contextual factors and proximal processes. The authors found clear relations between personal characteristics (age, sex and academic achievement) and contextual factors (including socio-economic status, ethnicity and the school culture).

Bronfenbrenner's impact on research in child and youth care is evident in the ways in which various studies have tried to 'better understand the impact of the interaction' between the various systems 'on children's development'. A variety of positive influences flow from the use of Bronfenbrenner's theory in child and youth care practices (Derksen, 2010: 335). This includes the recognition that systemic change is necessary in order to support and sustain change in individuals (Radmilovic, 2005), and that 'to significantly influence the quality of human services delivered to children requires a comprehensive ecological approach that can influence each of the environmental systems that impinge on children and affect their lives' (Van de Ven, 2007: 254, cited in Derksen, 2010: 333).

However, a study conducted by Landry and Cooper (2014) to understand school readiness in a pre-K (pre-kindergarten: schooling for children under the age of 5 years old) setting indicates that Bronfenbrenner's ecological systems theory helped to differentiate the roles that structural quality and process quality have on children's development but failed to identify the specific features of pre-K settings that affect specific dimensions of school readiness, and for whom. This, according to Landry and Cooper (2014), is partially due to the application of ecological theories to key features and experiences of children's developmental needs and the emphasis on how structural features of pre-K are distinct to the developing child, thus indicating an indirect impact on school readiness. In the study of Landry and Cooper (2014), the findings point to the child's developmental level and the structural features as not being reciprocal, but rather that of having major pitfalls.

Hirsto's (2001) study of children in their learning environments, with a focus particularly on teachers' representations of their students' home environment, found aspects of Bronfenbrenner's theory on home and school collaboration not to be very evident, concluding that such collaboration will only be transparent through significant others that are active participants in both systems.

From the studies discussed in preceding sections, it is clear that Bronfenbrenner's ecological systems theory enables research 'on the ways in which reciprocal interactions between these systems influence development' (Derksen, 2010: 336).

For the purpose of this study, Bronfenbrenner's ecological systems theory concedes that lifespan development is neither driven mainly by inner dispositions nor subject to control by innate dispositions. Instead, the ecological systems theory perceives individuals as products and producers of their own environments, whereby the person and the environment establish a network of interdependent impacts.

2.5 CRITIQUING BRONFENBRENNER'S THEORY

Critics of Bronfenbrenner's theory state that while it is useful in highlighting the developmental stages of life and the different environments in which the child develops, it does not provide reasons for behaviour (Tlale, 2013). The current study proposes exploring reasons for behaviour by, for example, seeking answers to questions such as why teachers and students opt for certain support and intervention opportunities and not others, and why parents do, or do not, provide support for their children's education.

Another criticism of Bronfenbrenner's theory is that it gives little attention to biological and cognitive factors in children's development (Joyce, Lynch & Veale, 2015: 81). The theory is also criticised as not addressing the step-by-step developmental changes that are the focus of theories such as Erikson's and Piaget's (Syed, 2016). The current study did not analyse step-by-step developmental changes, but focussed on a brief period in the development of the child, namely the adolescence phase, also experienced in Grade 12.

Krishnan (2010) asserts that evidence suggests that socially and economically disadvantaged areas are more likely to have proportionately large numbers of developmentally at-risk children. Developmental studies routinely control socio-economic status as a way of accounting for the variation in environmental stressors. Rather than using various abstract variables in the form of numbers or proportions, a single index quantifying the complex conditions or circumstances can be more meaningful in understanding the conditions that shape children's development.

Investigations based on bio ecological theory are limited due to paucity of data. It is also important to note that there is a dearth of primary data to fully understand interactions at all

levels of social ecology; as data are largely drawn from a secondary source, thereby limiting the availability of variables. The absence of variables pertaining to individual responses is a notable limitation. In addition, data are mainly cross-sectional, and therefore, hard to establish causal relationships (Krishnan, 2010).

According to Lindgren (2010), the theory of development ecology may be questioned because of how it looks at the individual's role in relation to other actors in order to define and understand the forces underlying the professional development and constitution of academic disciplines. Factors relating to both the inside of the individual and social ties between individuals and in relation to global factors need to be discussed. Through the development of, for instance, information technology and access to information, the individual will be given more freedom regarding their space of activity and independence, but also less freedom and space of activity because individuals behave in different ways when acting. Some individuals, to a very high extent, see possibilities while some individuals primarily see difficulties and obstacles.

Additionally, Lindgren asserts that the surrounding environment related to a societal framework (local, national and international) and/or organisational context (family, friends, personal network, and workplace) in relation to the individual's capacity plays a key role in the development process as a whole. Bronfenbrenner's model lacks these aspects of intra-level understanding and entrepreneurial factors since it does not see the individual as an independent actor. Resilience capacity on a mental, intra level and an entrepreneurial way of building, developing and keeping networks gives the different levels in the development ecology model a broader understanding of what stimulates learning processes.

After considering the criticism of Bronfenbrenner's ecological systems theory, it was evident that the strength of this model and the soundness of its concepts should form part of this study's theoretical framework. In this regard, the framework developed provides a suitable and comprehensive framework for exploring the integrated and influential interactions between students and their particular contexts in mathematical teaching and learning. The following views of Bronfenbrenner (1979) contribute to this study.

Specific intervention measures may impact on different schools in a particular locality in terms of:

- The direct relationships and interactions children have with people in their immediate environment. In this study references were made with respect to parental involvement and interaction.
- The mathematics teachers' interactions with the mathematics students in the mathematics class.
- The support opportunities and intervention programmes for the schools initiated by the Department of Basic Education, Western Cape Education Department and other agencies for mathematics teaching and learning.

2.6 CONCLUSION

The suitability of using a theoretical framework, with its integrative and comprehensive use of concepts, was considered a useful analytical tool to investigate and answer the research questions of the study: What is the availability of, access to, and utilisation of support opportunities by the mathematics teachers and students at the selected schools? And, what mathematics support opportunities would be most appropriate for mathematics teachers and students at these schools? In this chapter selected theories were highlighted in an attempt to justify the most appropriate framework in which this study could be explored and investigated. The study briefly examines Vygotsky's Zone of Proximal Development and Glaserfeld's radical constructivism theories in terms of its applicability to evaluate the above research questions. Bronfenbrenner's Ecological systems theory was selected as the most suitable guiding framework for this study and was discussed in terms of its validity. Bronfenbrenner Ecological Systems was analysed and critiqued for its plausibility in addressing pertinent issues encompassing the research questions of this study.

The next chapter presents a review of the literature on the factors that have an impact on the teaching and learning of mathematics in disadvantaged communities and support opportunities for mathematics teachers and students.

CHAPTER 3

LITERATURE REVIEW

3.1 INTRODUCTION

There are challenges in mathematics teaching and learning in South African schools, especially those in the previously disadvantaged areas. Among these are parental involvement (Ramadikela, 2012: 109), teacher competencies and qualifications (Education For All, 2005), and availability of resources (Reddy, Juan & Meyiwa, 2015). The eventual consequences of these challenges are the low mathematics pass rates at previously disadvantaged schools and the relatively small number of students who study pure mathematics at the Further Education and Training (FET) level. Various forms of support for mathematics teaching and learning have been introduced by the government and private institutions to overcome some of these challenges and to improve achievement.

This chapter focuses on studies on factors that might have an impact on the teaching and learning of mathematics in previously disadvantaged schools and support opportunities for mathematics teachers and students. In general, studies about academic achievement in mathematics in South Africa conclude that students perform below the international standard (Reddy et al., 2015), the pass rate for mathematics students is poor (Wilkinson & Ogunkola, 2014), and that few students opt for pure mathematics at the FET level (Campbell & Prew, 2014). The literature review further explores the reasons for poor academic achievement in mathematics, including the socio-economic background of students, parental involvement, teacher competencies and qualifications, and availability of resources. Furthermore, the review investigates studies that focus on public and private sector support opportunities for mathematics teachers and students in the South African and international context.

The review of the literature is in line with the theoretical framework of this study, based on Bronfenbrenner's ecological systems theory (Section 2.4), which calls for a field-theoretical approach in which the interaction of processes, person and context are taken into consideration. Bronfenbrenner's ecological systems theory is a useful research model for understanding how developmental processes (e.g. teaching and learning) and outcomes (e.g. students' achievement) vary as a joint function of the characteristics of not only the school itself but also those of the ecological systems or environment surrounding the school. In applying Bronfenbrenner's ecological systems theory, this study focused on the microsystemic

and mesosystemic levels of interactions between the home and school environments. At the home level, emphasis has been placed on factors such as socio-economic background and parental involvement and support. At the school level, the emphasis was placed on factors associated with teacher competencies and availability of resources. Both of these levels highlight aspects of the teaching and learning of mathematics for all stakeholders within these spheres of Bronfenbrenner's ecological systems theory. In addition, an investigation was done at the exosystemic level of the interventions and support provided to the teachers and students by the Department of Basic Education, Western Cape Department of Education and other agencies or non-governmental organisations (NGOs) to promote mathematics learning and teaching.

3.2 REASONS FOR THE PROVISION OF MATHEMATICS TEACHING AND LEARNING SUPPORT

According to Bernstein (2013), enhanced numeracy and mathematical abilities are very important for getting ahead in the educational system and for obtaining job opportunities. Further, he states that learning mathematics is a key factor for employment opportunities and remains a global phenomenon. Therefore, South Africa's development as a knowledge economy depends partly on achieving high levels of performance in mathematics and numeracy.

The general consensus is that South Africa performs poorly in mathematics education. The Trends in International Mathematics and Science Study TIMSS (2011) showed that South African students have the lowest performance among all 21 middle-income countries that participated in the study. More disconcerting was that the average mathematics performance of South African students in Grade 9 was below the international benchmark of 500 points (Mullis, Martin, Foy & Arora, 2012). In TIMSS (2011) students achieved an average score of 352 out of a possible 1000 points. In comparison to the TIMMS (2011) mathematics results, the TIMMS (2015) reported an improvement of 20 points (372), which still leaves South Africa at the bottom of the barrel, being in the 38th position out of 39 countries.

Reddy et al. (2015) point out that the national mathematics mean scores are low and the national average mathematics achievement score at different grades across the schooling system, for a long time had not shown any improvement. Performance in the national

achievement studies is low and even though the methodologies and instruments in each of the studies are different, these scores demonstrate the low performance of the education system. In 1995, the government set a target that by 2014, 60% of students should be achieving above the 50% mark. In 2011, 17% of Grade 3 students and 12% of Grade 6 students achieved above the 50% mark and in 2012, according to the methodology used by the DBE (2012), 36% of Grade 3 students achieved above the 50% mark. This is far from the target set by government in 1995.

What is more concerning is that in 2011 and 2015, South Africa was only one of three countries, along with Botswana and Honduras, where Grade 9 students wrote Grade 8 tests (TIMMS, 2015, 2011). Since TIMMS (2002), South Africa's Grade 9 students started to write the Grade 8 TIMMS assessment, as the Grade 9 tests were considered too difficult for the Grade 9 students (Spaull, 2013). This did not improve South Africa's overall ranking. South Africa's performance was so poor that the Grade 8 students of all the participating countries, except Ghana, outperformed South Africa's Grade 9 students (Muller, 2014).

TIMSS uses the five 'international benchmarks' to measure the scores of the test takers, namely: Advanced (above 625 points), High (550 to 625 points), Intermediate (475 to 550 points), Low (400 to 475) and Not Achieved (less than 400). The Human Science Research Council introduced an added benchmark, which are scores between 325 to 400 points to identify the group of students that can be targeted for upward shifting to a higher benchmark (Reddy et al., 2015). As a result, the *Not Achieved* benchmark is for less than 325 points as opposed to 400 in a local context. The following is the international benchmark distribution of South African Grade 9 mathematics students' achievement in TIMSS (2015) (Table 3.1).

Table 3.1: Summary of South African Grade 9 mathematics achievement in TIMSS (2015)

International Benchmark	Grade 9 Mathematics
Advanced (>625)	1%
High (550-625)	3%
Intermediate (475-550)	10%
Low (400-475)	21%
Potentials (325-400)	28%
Not Achieved (<325)	37%

Source: Adapted from Letaba (2017)

The proportion of students who obtained Intermediate, High or Advanced international benchmark levels is low: 14% for Grade 9 mathematics, with only 35% of mathematics students achieving a score of over 400 points. This means that only one-third of South African Grade 9 students demonstrated achievement at the minimal level in mathematics and science (Reddy et al., 2016). For Grade 9, at the Advanced international benchmark level, students are expected to apply and reason in a variety of problem situations (fractions, percentages, proportions, geometry, averages, expected values, etc.), solve linear equations and make generalisations. About 54% of Singaporean Grade 8 mathematics students achieved Advanced level, a very high value compared to 1% of South Africa.

Another major issue of concern, which again emphasises the need for support for mathematics students and teachers, is the poor pass rate in mathematics, particularly in Grade 12. A further concern is the quality of the mathematics passes. For example, in 2014, only 23%, or 120 535 of all those who wrote the NSC examination (532 860), obtained above 53.5% for pure mathematics (DBE, 2015). Researchers in the field of mathematics education argue, and rightly so, that this does not bode well for South Africa in its quest to produce more doctors, engineers and technicians. The statistics in Table 3.2 reveal that between 2012 and 2015, between 49.1% and 59.1% of students who wrote pure mathematics in the NSC examination obtained 30% and above.

Table 3.2: Achievement in mathematical literacy and pure mathematics in the period 2012-2015

Subject and Achievement	2012	2013	2014	2015
Number of students who wrote mathematical literacy	291 341	324 097	312 054	388 845
Number of students who achieved above 30%	254 611	282 270	262 495	277 594
Percentage of students who achieved above 30%	87.4%	87.1%	84.1%	71.4%
Number of students who wrote pure mathematics	225 874	241 509	225 458	263 903
Number of students who achieved above 30%	121 970	142 666	120 523	129 481
Percentage of students who achieved above 30%	54.0%	59.1%	53.5%	49.1%

Source: DBE, 2015

Table 3.3: Overall achievement rates in mathematical literacy 2014 – 2017

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above	No. achieved at 40% and above	% achieved at 40% and above
2014	312 054	262 495	84,1	185 528	59.5
2015	388 845	277 593	71.4	172 214	44.3
2016	361 948	257 926	71.3	167 811	46.4
2017	313 030	231 230	73.9	140 991	45.0

Source: DBE, 2017

Table 3.4: Overall achievement rates in pure mathematics 2014 - 2017

Source: DBE, 2017

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above	No. achieved at 40% and above	% achieved at 40% and above
2014	225 458	120 523	53.5	79 050	35.1
2015	263 903	129 481	49.1	84 297	31.9
2016	265 912	136 011	51.1	89 119	33.5
2017	245 103	127 197	51.9	86 096	35.1

In 2016 (71.3%) and in 2017 (73.9%) of mathematical literacy students passed the NSC examination (Table 3.3). However, the quality of the pass was above the 30% but less than 40% range, indicating a below average pass rate for the majority of students who were enrolled for mathematical literacy in these years. Students who wrote pure mathematics in

the same years (2016 and 2017) performed at a much lower standard than the mathematical literacy students, with only 51.1 in 2016 attaining a pass above 30% and a low 33.5% at the 40% and above pass mark (Table 3.4). Overall results for the quality of pass mark for mathematical literacy and pure mathematics convey a general decline in both instances, a sure matter for concern for the future of mathematics in our country.

Another concern is the imbalance between the number of students enrolled for mathematical literacy and for pure mathematics. The latter is viewed as an important entry level requirement for access to tertiary qualifications in fields such as engineering, business and science, with the focus on abstract and hypothetical thinking. Mathematical literacy has been implemented with a focus on developing 'an awareness and understanding of the role that mathematics plays in the modern world' (Vithal, 2006). Mathematical literacy is a subject driven by life-related applications of mathematics (Department of Basic Education [DBE], 2012). As the figures in Table 3.1 to Table 3.4 illustrate, between 2012 and 2017 an increasing proportion of students took mathematical literacy.

A number of issues emerge from these findings. The common understanding is that mathematical literacy is for the 'less numerically inclined' students (North, 2015). Mathematical literacy was thus introduced to offer students an opportunity to get a mathematics education without having to do pure mathematics. Some have also argued that there is a trend towards pushing students to take 'easier subjects', which means no pure mathematics or physical science, as they are usually taken as a combination, so that the pass rate of the school is not negatively affected (Child, 2017; Reizig, 2017). Ndzomo (2016) argues that this is a DBE strategic move to improve pass rate figures, both overall and in mathematics, by shifting an increasing proportion of students into mathematical literacy. Moreover, Ndzomo (2016) claims that the reason for this shift arises from the fact that there are very few teaching resources available to teachers to teach pure mathematics and, in particular, that teachers are not adequately trained to teach pure mathematics.

Additionally, if a student fails pure mathematics, they would have a better chance of passing mathematical literacy (Clark, 2012). This, however, limits their career opportunities. According to Clark (2012), mathematical literacy has great practical applications for real world situations. For example, one can use these skills to plan for future finances. Mathematical literacy is only accepted as an admittance subject in some courses at universities and TVET colleges. This is a

potential problem for students who are interested in tertiary education. Only a few courses in the Faculties of Humanities and Law will accept students with mathematical literacy on a National Senior Certificate (NSC). For example, based on the entry level requirements of various South African universities, a student who passes pure mathematics with 45% will not be admitted for economical science or engineering, and thus would have to do a bridging course to obtain at least 60%. This has the effect of perpetuating the cycle of challenges the country faces due to a lack of skilled professionals such as engineers, medical doctors and accountants.

3.3 REASONS FOR POOR ACADEMIC ACHIEVEMENT IN MATHEMATICS

Mbugua, Kibet, Muthaa and Nkonke (2012) conducted a study to investigate the reasons contributing to poor achievement in mathematics in secondary schools in Kenya. The results indicated a number of reasons, which include: under-staffing of mathematics teachers; inadequate teaching/learning materials; lack of motivation and poor attitudes by both teachers and students; and retrogressive practices that eventually lead to poor performance in mathematics education (Mbugua et al., 2012). Furthermore, the study revealed that availability of mathematical resources is limited to textbooks, and that 63.3% of students indicated that their mathematics teachers were competent in teaching mathematics. Students' personal factors contributing to poor performance in mathematics were gender, economic factors and attitude towards mathematics.

The research methodology used in Mbugua et al. (2012) consisted of questionnaires administered to three students each of 26 secondary schools, and 132 mathematics teachers and 26 head teachers. In Mbugua's study, the student questionnaire comprised sections on demographic data with items such as gender, age, secondary school entry marks, socio-economic, cultural and school-based factors such as method of teaching by teachers, availability of teaching/ learning materials, academic qualifications, teaching experience of mathematics teachers, and motivation. Mathematics teachers' and head teachers' questionnaires also contained sections on demographic data such as gender, age, academic qualification, and teaching experience. Socio-economic, cultural, and school-based factors included items such as method of teaching, availability of teaching/ learning materials,

workload and motivation, and, finally, strategies to be adopted to improve achievement in Mathematics. Descriptive statistics were used to analyse the data obtained.

Although questionnaires are practical in obtaining large amounts of data, it is considered an inadequate methodology for obtaining data that leads to understanding of certain forms of information, such as changes of emotions and behaviour (Austin & Sutton, 2014). Mbugua's (2012) study, as a contribution to research in mathematics education, lacked the in-depth examination of a varied, detailed and extensive array of information obtained from different sources in order to present comprehensive explanations that portray a holistic picture of the situation at each school. In addition, using multiple research methods would provide a more thorough and comprehensive understanding of the research problem than either quantitative or qualitative approaches alone.

A study conducted by Singha, Goswami and Bharali (2012) investigated reasons for poor academic achievement in mathematics in higher secondary schools and colleges in the Jorhat District of Assam in India. The study revealed that 36% of mathematics students could not understand the subject due to a lack of practical applicability; while 30% of students stated that the normal time period of 45 minute or 1 hour allocated for mathematics classes in schools and colleges was not sufficient. Some mathematical problems are so complex and lengthy that they cannot be completed in the allocated time. Another 70% of the teachers were of the opinion that many students do not take mathematics willingly; rather they are forced by their parents, especially in the case of higher secondary students, and that extra coaching was required in the subject. This creates problems for students from poor backgrounds who cannot afford the costly coaching. Twenty percent of the students revealed that they did not get the expected marks in the examinations due to the absence of step marking, that is when the mathematics examiners do not give the mathematics student credit/marks for additional 'steps' in the calculation of a mathematical equation or problem.

Singha's et al. (2012) study demonstrates that 80% of the teachers are of the view that most of the students go to class with a negative attitude towards mathematics. They have fear for the subject, yet they take it in order to have better career options. Sixty percent of the teachers felt that mathematics lack practical tools like physics and chemistry to make the subject interesting for the students. Again, 20% of the teachers revealed that the normal time

period for lessons of 45 minute or 1 hour in schools and colleges is not sufficient to teach mathematics.

In a study conducted by Makgato and Mji (2006) on the reasons for poor achievement in mathematics in South Africa, two key reasons were highlighted. The first indicated a direct correlation with teachers' teaching strategies, content knowledge, motivation, laboratory use, and non-completion of the syllabus within a year. The second factor, associated with indirect influences, was attributed to the role played by parents in their children's education, and general language usage. The sample for this study was restricted only to schools that had poor achievement in mathematics in Grade 12. In order to acquire a clear understanding of the factors that contribute to low achievement in mathematics, it has to be measured against similar factors at schools where Grade 12 students perform well in mathematics.

A study conducted in South Africa using the TIMSS 2015 data indicates that the school environment, teacher competencies and qualifications, and availability of resources are key to providing an environment conducive for successful mathematics education and outcomes. The study by Reddy et al. (2016) examines differences in academic achievement among South African students in mathematics and science between the nine provinces of the country. The author compared schools with different levels of poverty and resources; public and independent schools; male and female students; students of differing age groups; students with differing home environment factors such as home pedagogical resources and level of parental education; schools with differing physical resources; schools with differing school environment and climate factors such as possession of prerequisite knowledge or skills, availability of basic nutrition, existence of disruptive and uninterested students, differing levels of absenteeism, and differing school safety conditions; schools with differing teacher content knowledge and career satisfaction; and students with differing home languages. Many of these factors were seen to account for differing levels of achievement in mathematics and science.

Reddy (2004) argues that there is no single cause of South Africa's poor and diverse achievement in mathematics. Low mathematics achievement could be linked to multiple, complex and connected sets of issues, including issues of poverty, resources and infrastructure of schools, low teacher competencies and qualifications, and poor learning cultures in schools. Bosker and Witziers (1996) argue that only eight to ten percent of school-

level factors contribute to student achievement, particularly for mathematics achievement. The remaining ninety to ninety-two percent are factors beyond the control of the school, such as the socio-economic environment in which the school is located and the home language of the students. The implication here is that education policy makers are not able to manipulate these variables to achieve educational outcomes. Similarly, Coleman Campbell, Hobson, McPartland, Mood, Weinfeld and York (1966) found that school-level factors have little influence on academic achievement, and that variations in family (socio-economic) backgrounds have a direct effect on student achievement.

Nevertheless, in general the literature that focuses on the reasons for poor academic achievement in mathematics draws attention to the fact that education in general is shaped by students' home and school environments. These are two of the environments that are central in the theoretical framework of the current study. The two key aspects of the home environment that impact academic performance are the socio-economic background of the students and parental involvement, while the related key aspects of the school environment are teacher competencies and qualifications, and availability of resources.

3.3.1 Socio-economic background

This study was conducted within schools that are located in previously disadvantaged areas in the Cape Flats in the Cape Town Metropole, South Africa. It is therefore crucial to highlight the socio-economic status of parents and the communities, and the role it plays in the type of support students receive in mathematics learning. According to Reddy et al. (2015), there is a great differentiation of the educational performance of students from different socio-economic conditions, and it can be said that South Africa has two systems of education. One part is described as well-performing, and this relates to approximately 30% of schools; the other part is described as underperforming, that is, the remaining 70%. Ball, Goffney and Bass (2005); Barwell (2010); Gerber, Engelbrecht, Harding and Rogan (2005) and Winsor (2007, 2008) maintain that disparities in mathematics achievement continue to be closely linked to social class and race. Davis (2000) agrees, contending that the socio-economic background or status of the community and families of students has a direct and appreciable impact on the degree of involvement and support given to their children's education. Social class impact on parental involvement is extremely low among parents in disadvantaged communities in South Africa (Singh, Mbokodi & Msila, 2004: 304). A study conducted by Epstein (1992, cited in Anthony and Walshaw, 2007) shows that students perform better academically in

mathematics and had more positive school attitudes if they had parents who were aware, knowledgeable and involved. A critical aspect of Epstein's study is that it does not take the parents' prior learning experiences in mathematics and mathematics education into consideration.

It is generally believed that there is a positive relationship between socio-economic background and academic achievement. Graven (2013), however, points out that in South Africa mathematics studies tend to focus on the largest socio-economic status groups, which are the poorest. As a measure of rationale for the outcomes of these studies, Hoadley (2007) contends that students from schools located in different socio-economic environments are given differentiated access to school knowledge in mathematics classrooms. She argues that the post-apartheid curriculum, with its emphasis on everyday knowledge, has had a disempowering effect on marginal groups who are not exposed to a more specialised knowledge of mathematics. Teachers in low Socio-Economic Status (SES) schools struggle to make sense of the changes in the curriculum in the post-apartheid era, resulting in even further mathematics learning gaps between 'advantaged' and 'disadvantaged' students. This fact is confirmed by Goswami (1982), who found that children from higher socio-economic groups generally tend to perform significantly better than those from low socio-economic groups.

Although in general there appears to be a positive relationship between students' socio-economic background and academic achievement, this explanation, although valid, fails to take into account large disparities in achievement between those from similar socio-economic backgrounds. Some high-achieving students come from the same disadvantaged communities and share similar low socio-economic backgrounds, schools and classrooms with their low-achieving peers. A case in point is Spine Road High School in Mitchells Plain, which is located in a previously disadvantaged area in the Cape Flats. The school draws students from poor backgrounds that have a high rate of teenage pregnancy, gangsterism and other various social ills. Despite the socio-economic background of its students, this school achieved a 100% mathematics pass rate in 2012, and a 95% mathematics and 84% science pass rate in 2014 (Olwen, 2015).

3.3.2 Parental involvement

There are several studies which conclude that generally parental involvement in the education of their children has positive effects on students' academic achievement (Deslandes & Bertrand, 2005; Reay, 2005; Sanders & Lewis, 2005). Henderson and Mapp (2002: 7) found the following benefits for students with involved parents, irrespective of their income or background: better results and performance in tests; better enrolment in higher level courses; better passing and promotion to the next grade; regular attendance at school; better social skills; improved behaviour both in and out of school; and completion of their basic education and entrance to institutions of higher education.

In the context of the performance of students in mathematics, Biddulph, Biddulph and Biddulph (2003), found that rich learning environments that incorporate meaningful mathematical experiences are associated with higher achievement and that a healthy home/school collaboration boosts children's achievement significantly. The results from a study conducted by Cai (2003) indicated that parental involvement is a statistically significant predictor of their children's mathematical achievement and also promoted positive behaviour and emotional development. If parental involvement does indeed buffer the effects of children's mathematics anxiety on their mathematics achievement, the importance of supporting parental involvement initiatives becomes even more evident.

However, Makgato and Mji (2006) point out that many parents in South Africa fall short as they do not know mathematics and physics, and consequently are not sure how can they be involved. By contrast, Mchunu (2012: 98-99) found that parents of students from disadvantaged schools in South Africa were involved in their children's learning in secondary schools, including talking about schoolwork, encouraging their children and giving them support and guidance, monitoring their progress, supervising homework and time spent watching TV, motivating and getting extra help such as tutors for them, and setting high expectations for their children. The conclusions reached by Mchunu mirror the findings of Epstein (2008), Catsambis (2001) and Comer (2005), who challenge assumptions that parents from low socio-economic background are less involved in their children's learning. However, the limitation of Mchunu's study is that it was restricted to a select group of students from disadvantaged backgrounds who were awarded scholarships to attend independent schools.

Studies identified specific parental involvement activities, like increasing positive communication between the home and school, providing home-based support for learning, and providing home-based celebrations for accomplishments, as essential to supporting positive mathematics outcomes in children (Ginsburg-Block, Manz & McWayne, 2010).

Although they have provided evidence that parental involvement does indeed influence children's mathematics performance, previous studies have not specifically examined the underlying mechanisms through which parental involvement impacts children's achievement. A study conducted by Soni and Kumari (2015) endeavoured to identify how parental involvement affects their children's mathematics performance. The investigation established that children's attitude towards mathematics serves as an underlying pathway between parental mathematics attitude and their children's mathematics achievement. Soni and Kumari (2015) found that the crucial variable determining achievement in mathematics is the parents' attitude towards mathematics.

The complexity of factors that can influence mathematics performance is demonstrated by Singh et al. (2015), when they show that high achievement in mathematics is a function of many interrelated variables related to students, families, and schools. The study, however, has certain limitations in terms of the methodology. Students and their parents were provided only with questionnaires that measured their attitudes towards mathematics. Furthermore, the results of the research focused mainly on aspects of the parents' attitude towards mathematics, with the exclusion of other external factors, such as the cultural, socio-economic and educational background.

Kleanthous (2010) concludes that perceived parental aspirations did not have a statistically significant effect on students' achievement in mathematics. This finding contradicts other researchers such as Fan and Chen (2001), who found that parental aspirations have an impact on students' mathematics achievement. Cao et al. (2006) distinguish between direct and indirect parental influence. They argue that direct parental influence, such as helping children with mathematics difficulties, has a less important impact on students' mathematics performance. Indirect parental influence such as parental encouragement, expectation and parents' attitudes towards mathematics have a significant impact on students' achievements and attitudes towards mathematics.

Due to the complexity of parental influence, there is no standardised scale in literature for measuring perceived parental aspirations. Kleanthous's (2010) study explored students' perceived parental influence on their achievement in mathematics, inclination to mathematics, and dispositions to study further mathematics among 563 students in Cyprus. The reliability of the scale designed to measure perceived parental influence was investigated using the Rasch model. It was found that perceived parental influence had a statistically significant effect on students' inclination to mathematics, but it did not have a statistically significant effect on students' mathematics achievement and dispositions to study further mathematics in higher education.

Although these studies highlight the influence of parental support irrespective of socio-economic backgrounds, in the South African context a different picture is depicted as efforts by policy makers and school administrators to involve parents in their children's education are portrayed as being ineffective. This is especially true in disadvantaged communities because of parents' lack of the necessary literacy levels required for participation and the fact that many are unemployed, thus reducing their role in negotiating from a position of strength. Ramadikela (2012: 109) emphasises that there is very limited involvement of parents from disadvantaged communities in the education of their children.

3.3.3 Teachers' competencies and qualifications

In South Africa, indicators on school achievement and teaching reveal largely unacknowledged poor teaching of mathematics in the majority of schools. Poor teaching competencies and, as an extension, learner results, will not quickly be remedied. Yet mathematics is a key requirement not only for entry into higher education, but also for most modern, knowledge-intensive work (McCarthy & Oliphant, 2013).

Various factors related to teachers contribute to findings about reasons for poor academic achievement, which include the lack of content and pedagogical knowledge and skills among mathematics teachers, a lack of professional development programmes for mathematics teachers, and teachers' lack of confidence in grappling with ever-changing curriculum reforms (Kritzinger, Moodley & Vinck, 2014). Darling-Hammond (2000) found that teacher characteristics, such as the relevant qualifications and experience, have a significant impact on learner achievement. In terms of teacher qualifications, the Education for All (EFA) 2000 assessment found that South Africa has a critical shortage of professionally skilled

mathematics teachers, with an audit revealing that only 50% of teachers who teach mathematics are trained in mathematics (EFA, 2005). Furthermore, research conducted by Moloji (2005) startlingly revealed that out of the 7 090 teachers teaching mathematics in the Eastern Cape, only 5 032 were adequately qualified to teach the subject, that is, they were in possession of a mathematics qualification. These statistics depict a possible reason for the lack of many teachers' pedagogical skills and content knowledge in Mathematics as a subject.

There is no doubt that teacher competency in mathematics education is closely linked to student understanding and learning of the subject. According to Ball (1993), Grossman, Wilson and Shulman (1989) and Roseberry, Warren and Conant (1992), teachers need to have a firm understanding of the subject domain and the epistemology that guide mathematics education. This relates to their understanding of different kinds of instructional activities that promote student achievement. Furthermore, under-qualified teachers are not equipped to effectively utilise teaching methods. Schechter and Bochenek (2008) argue that universities are not training teachers adequately, and district officers are largely unqualified and thus unable to provide adequate support to teachers and schools. Other problems are related to mathematics students seldom choosing teaching as a career, and therefore resulting in an under-supply of qualified mathematics educators (Makgato & Mji, 2006).

In a study conducted by Mogari (1997), evidence shows that inadequate levels of teacher content-knowledge abound in South Africa, including misconceptions a group of practicing mathematics teachers have about infinity (∞). Makwakwa and Mogari (2011) found that Grade 11 teachers struggled to teach probability because of their poor content knowledge. From this study, it is evident that teachers with limited content knowledge will not be in a position to simplify aspects of content and also make the content interesting and relevant by relating it to real life contexts. Furthermore, findings by Onwu and Mogari (2004); Taylor (2011); and Bansilal Brijlall and Mkhwanazi (2014) indicate that South African mathematics programmes are less rigorous than those in countries such as Finland and Japan in terms of the extent to which they prepare teachers. For example, a typical Finish teacher is a subject-focused and content expert, and one needs a minimum qualification of a master's degree to teach either in primary or secondary school while a bachelor's degree is an entry requirement for a teaching position in preschool and kindergarten (Sahlberg, 2010). In Japan the requirements are very similar to that of Finland in terms of teacher qualification for the teaching of mathematics.

In the context of this study, it is however important to keep in mind that there is a considerable variability of teacher mathematics qualifications, especially with reference to those mathematics teachers that have been trained at former teacher training colleges in the apartheid era. The type of qualification obtained from these teacher training colleges may be equivalent to one year at university and may be viewed as inadequate to major or specialise particularly in mathematics education. This statement is supported and generally accepted by the Department of Basic Education (DBE) and the Department of Higher Education and Training (DHET) (2011). The DBE and DHET assert that there is both an absolute shortage of teachers, and a relative shortage of qualified teachers competent to teach specific subjects (including mathematics) and especially in specific phases, such as the foundation phase.

Furthermore, the implementation of the Outcomes Based Education curriculum (OBE), and most recently the new Curriculum and Assessment Policy Statement (CAPS), as shown in Table 3.5, require teachers to change their existing beliefs, knowledge and practices that are typical of a traditional classroom (Graven, 2004). It seems that most teachers still function within a traditional performance-based model of education, which is not congruent with the curriculum reforms in South Africa (Taylor & Vinjevold, 1999). Dhlamini, Jojo, Kaino, Ngoepe and Phoshoko (2015) summarises the impact of curriculum changes on mathematics teachers as follows:

- Failure of appropriate teachers' work support, inspection and monitoring.
- Lack of continuous training of teachers in service.
- Changing curricula without proper training and communication.
- No continuity for teachers as well as students.
- Demoralisation and disillusionment among teachers.
- Negative and worsening perception of the teaching profession as a whole.

Table 3.5 Summary of core changes from NCS to CAPS

Concept / feature / dimension	NCS	CAPS
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Structure of qualification	Gr R to 9 (as outlined in RNCS 2002) GETC mentioned in overview document, with exit level at Gr 9 (GET) never realised in practice	CAPS = Gr R to 12 GETC is not mentioned in CAPS Only exit-level is at Gr 12 (NSC) Theoretical shift to 13 years of schooling as the new norm
Critical outcomes	Explicitly mentioned	Incorporated in aims and curriculum content and skills
Development outcomes	Reflect on and explore a variety of strategies to learn more effectively. Participate as responsible citizens in the life of local, national and global communities. Be culturally and aesthetically sensitive across a range of social contexts. Explore education and career opportunities. Develop entrepreneurial opportunities.	Not mentioned
Purpose(s)	Outlined as: equipping students, irrespective of their socioeconomic background, race, gender, physical ability or intellectual ability, with the knowledge, skills and values necessary for self-fulfilment and meaningful participation in society as citizens of a free country; providing access to higher education; facilitating the transition of students from education institutions to the workplace; and providing employers with a sufficient profile of a learner's competences	No explicit list of purposes given (but a similar list is included in NSC SAQA document)
Principles	NCS = OBE, described as "participatory, learner-centred and activity-based education"	CAPS expects "encouraging an active and critical approach to learning, rather than rote and uncritical learning of given truths"
Inclusivity	Mentioned in passing	Foregrounded and described in detail as one of the general aims
Outcomes / objectives	Learning outcomes	Concepts, content and skills
Assessment link	Assessment Standards	Content / Assessment
Planning	Phase plan	Overview across grades
Work schedules		Overview of year plan
Learning programme development		Subject interpretation of curriculum content for instructional designs

Lesson plans		Lesson plans
Integration	Principle of coherence between the learning areas made explicit	Not mentioned
Role of teacher and learner	Teacher role described as: “key contributor to transformation of education in South Africa”; “qualified, competent, dedicated and caring”; “able to fulfil the various roles outlined in the Norms and Standards for Educators: these include being mediators of learning, interpreters and designers of Learning Programmes and materials...” etc.; “considerable room for creativity and innovation on the part of teachers in interpreting what and how to teach”	No mention of the envisaged teacher Little room for interpretation of what and how to teach
Role of learner	Learner to participate as group member (focus on group work)	Focus on learner taking individual responsibility for learning
Approach in learning	Discovery-based learning	Content-driven learning; no emphasis on critical thinking about knowledge validity and bias

Source: Adapted from Du Plessis (2015)

International research shows that teachers are the main drivers of the variation in learner achievement in schools (Mourshed & Barber, 2007). In consequence, pre-service teachers who enrol at two Australian universities, New South Wales institute of teachers and Charles Sturt University without the appropriate mathematics competence, are required to pass a basic skills test covering Grade 6 mathematics topics, with a pass pegged at 90%. Students failing the test after four attempts have to enrol for an enrichment course aimed at improving their mathematical competence as well as assisting them in developing their professional identity as mathematics teachers equipped with both procedural and theoretical knowledge. Within the context of redressing the devastating effects of apartheid schooling and teacher education, mathematics competency levels for mathematic teachers need to be improved on a yearly basis to effectively measure the impact it has on mathematics student achievement.

In 1991, the American National Council of Teachers of Mathematics together with the Association for Supervision and Curriculum Development published *A Guide for Reviewing School Mathematics Programs*. In this document they state that in order to have high-quality mathematics programmes, teachers of mathematics must be well-prepared, and demonstrate positive attitudes, continue to grow professionally, and be actively involved in educational issues that affect the quality of their students’ learning (NCTM & ASCD, 1991). Teacher quality

is seen as the most important component in the pursuit of improved learner performance. Moreover, research suggests that teachers with better quality qualifications tend to be more effective in their teaching (Armstrong, 2015). From the findings above, it is evident that the lack of adequate in-service training and qualifications can be considered barriers to learning.

3.3.4 Availability of resources

In a study that makes use of TIMSS data drawn from surveys conducted among students and school representatives on the learning environment at schools in South Africa, Reddy, et al. (2016) found that South African schools have a severe challenge in terms of resources, especially rural schools, which have the lowest levels of academic achievement. They found that in 2002 only one-third of mathematics and science students had access to critical resources for mathematics and science classrooms, and that 95% of students were negatively affected in terms of mathematics performance due to lack of physical infrastructure such as classroom space and mathematics textbooks.

With regard to the impact of the availability of resources, a study conducted by Coetzee (2009), found that teachers were concerned about class sizes. A substantial proportion (29%) of the teachers expressed frustration with big classes, due to lack of human and physical resources compared to the 11% of students who felt the same way about the big classes. Almost a quarter (24%) of the teachers indicated that they did not have enough class time to assist students individually, compared to 11% of the students who indicated that they did not get individual help. A quarter (25%) of the teachers indicated lack of textbooks as a contributory factor to unsatisfactory performance in mathematics education. In addition, in South Africa there is a widespread complaint about unsuitability of textbooks in the field of mathematics, especially at school level.

An analysis of TIMSS results of 1998 (Johnson, 1998) indicates that South African textbooks have very few activity-based exercises and almost no assessment suggestions. It further elaborates that South African textbooks encourage mainly lower order skills (such as recall), as opposed to the higher order skills (such as problem solving). The Department of Basic Education (2009: 28) states that 'the quality and quantity of learner and teacher support materials in South Africa are not adequate to support quality learning'. In a recent study, it was revealed that in many instances, South African textbooks are continued to be used as a cookbook approach where teachers supply students with formulae such as the surface area

of a cylinder is $A = 2\pi r^2 + 2\pi rh$. Students are not given an opportunity to make inferences, conjectures and generalisation to understand strategies used to derive the formula (Siyepu, 2013).

Enu, Agyman and Nkum (2015) emphasise the impact of adequate teaching and learning resources on the mathematics achievement of students at three colleges of education in Ghana. The results reveal that most of the teaching resources that enhance students' understanding of mathematics concepts, like geometry sets and mathematics models, were minimal, representing 2% and 20% respectively. Others like projectors and computers were never used. Contrary to the findings of Siyepu (2013), Enu et al's. (2015) study highlighted that textbooks continue to lead with 78% in terms of their practicality. Hanushek and Rivkin (2006) agree and assert that (additional) resources do not make a difference to student achievement. They contend that measurable characteristics of teachers make a difference to student outcomes.

It was noted that while the presence of resources within schools arguably does not guarantee academic improvement, one potential area of improvement in mathematics education rests on the management of resources and the infrastructure of the school.

3.3.4.1 Digital resources

The challenges discussed in this section focus on the use of digital resources within the classroom. For the purpose of this study, elements of the discussion were viewed as two-fold. Firstly, focus is given to teacher experience and challenges of the situation and secondly, the challenges around the availability and use of digital resources within previously disadvantaged schools.

3.3.4.1.1 Teacher experience and challenges

Despite digital technology becoming increasingly available to teachers, they often do not make optimal use of technology for teaching and learning purposes. Research indicates that "although teachers in schools show great interest and motivation to learn about the potential of Information Communication Technology (ICT), in practice, use of ICT is relatively low and it is focused on a narrow range of applications" (Sime & Priestley, 2005: 131) Similarly, a study by Howie and Blignaut (2009) established that only 18% of Grade 8 Mathematics teachers use

digital technology in teaching and learning activities, with the main uses of this technology related to administration and processes of monitoring students' feedback.

Other issues originated from mathematics teachers' feelings of intimidation of the use of technology in the mathematics classroom. Some of the teachers in this study perceived ICTs as a threat and did not see the actual benefit of using it in their teaching and learning. They indicated that they were afraid of technology replacing the role of teachers in the schools (Stols, Ono & Rogan, 2015). In another study conducted by Mathematics Information and Distribution Hub (MIDHub), Stols et al. (2015), in an attempt to promote the effective use of online resources by Mathematics teachers and establishing a mobile online database that can support teachers in dealing with the challenge of selecting suitable information from millions of internet resources that are available, made some revelations.

The study investigated the perceptions of Mathematics teachers concerning their needs, beliefs and practices for using digital technology in the classroom. This was conducted at 22 high schools, 10 of them in the Eastern Cape in South Africa. The location of the remaining schools was unknown according to the information provided in the study. It was determined that the schools had common conditions of being in resource constrained environments. The study revealed that all the teachers viewed the use of technology in the mathematics classroom as highly positive. On a five-point Likert scale, 86.4% strongly agreed, and 13.6% agreed that technology can be a great asset in the classroom. They expressed excitement about the introduction of new technologies in teaching, yet at the same time, almost 73% admitted that they found the field of ICT overwhelming. Teachers agreed that using technology in the classroom could improve both teaching and learning (Stols et al., 2015).

According to Van Vechten (2013), most students from low socio-economic backgrounds do not have access to computers at their home environment. In this case students have limited exposure to computers and are thus limited to only using them at school. Teachers are then expected to train and teach the students how to use computers. This in itself poses a major challenge, as teachers have time constraints. In review of this, students' lack of experience with working on computers has caused teachers countless frustrations with regard to the use of technology for teaching and learning. Agreeably so, Lai and Kritsonis (2006) believe that "most teachers today do not have sufficient technological training to guide their students in exploring the computer and the assisted learning programmes."

3.3.4.1.2 Challenges related to availability and use of digital resources

The participating teachers in the same study above, by MIDHub, identified several external and internal challenges that potentially kept them from regularly using digital technology during mathematics instruction. Externally, unreliable electricity supply, classroom migration and the burden of connecting at the beginning of each period, as well as time limitations in terms of both preparation and teaching time, were regarded as inhibiting factors. In addition, several teachers referred to problems pertaining to subject content as their reason for not implementing technology, or to the fact that the energy and effort required to teach “difficult” classes left no room for innovation and new approaches. Internally, teachers experienced their perceived lack of sufficient computer and software skills, and their hesitance (in some cases even resistance) to move from traditional teaching to technology-supported teaching, as factors that had a negative effect on their use of technology in the classroom.

The MIDHub study also discovered that the teachers experienced that internet access was perceived as being too slow and that there was too much material to be covered in the curriculum. More than 50% of the respondents were of the opinion that their personal use of digital technology in teaching was hampered by a slow internet (either to some extent or to a large extent), while almost one third of the teachers confirmed that, to a large extent, the vast amount of curriculum content had a negative effect on their personal use of technology in teaching.

Notably from most of the above studies, with regard to the technological challenges experienced at previously disadvantaged schools, the lack of technical support staff and infrastructure (management and sustenance) and the quality and availability of internet access in the daily operation of the computer’s labs, were viewed as contributing factors.

3.4 RESEARCH FOCUSING ON STUDENT AND TEACHER SUPPORT

The low performance of students in South Africa discussed earlier, points towards a need for support for mathematics teachers and students in order to improve performance in mathematics. This section of the literature review focuses on the exosystemic level of the theoretical framework used in this study, which is the larger social environment, which also impacts students’ academic performance. Hence, this section will present pertinent literature on the support given to mathematics students and teachers in South Africa and abroad.

3.4.1 Support for mathematics students

Supplementary tuition refers to 'extra tuition' provided at a fee, given to one or small groups of school students by a provider outside the normal school hours. The sub-section below focuses on literature on the support given to mathematics students in South Africa.

3.4.1.1 South African studies on student support

Reddy, Lebani, & Davidson, (2003) conducted a study on behalf of the Human Science Research Council (HSRC), to assess the extent, nature and cost of supplementary tuition interventions in mathematics, science and computer studies for secondary school students. In this study, newspaper adverts were sent out to solicit information about the extent of the tuition sector, while letters were sent to known providers, and telephone interviews were held with some providers on the extent, nature and cost of their tuition programmes. The key findings from this research were that providers of supplementary tuition range from individuals offering supplementary tuition to big organisations with a client base of about 18 000. Individuals that offer supplementary tuition are either retired or practising teachers. The type of organisations that provide out-of-school tuition programmes include private sector organisations that offer their services for profit; franchises that offer tuition to a large client base; online instruction for students with access to computer facilities; non-governmental and community-based organisations; supplementary tuition driven by departments of education in partnership with service providers; and outreach programmes attached to universities and technikons.

The HSRC study found that at least 70 000 students utilise the services of supplementary tuition providers in South Africa. Most of the centres offer tuition after school hours and measure their success in terms of their contribution to passing the matric examinations (Reddy et.al 2003). The study focused mainly on what supplementary teaching programmes are available, who provides such programmes, and their costs. It did not focus on reasons why supplementary tuition is accessed by students, nor did it examine their benefits and limitations.

Coetzee (2009) also conducted a study on supplementary tuition at secondary schools in the Eastern Cape with the objective of determining the proportion of secondary school students who receive supplementary tuition in mathematics or mathematical literacy. Coetzee administered two surveys among teachers and students at ten high schools in East London.

The surveys sought to elicit information on the factors that motivated students to seek supplementary tuition in mathematics and mathematical literacy, and whether any differences existed between mathematics and mathematical literacy with regards to seeking supplementary tuition in these subjects. This study aimed at determining why students opted for supplementary tuition, the nature of the supplementary tuition offered, and which category of students took supplementary tuition. The findings suggest that some teachers apparently struggle to complete the syllabus in the allocated class time. Furthermore, the statistics indicate that about 47% of students feel that the new curriculum was much more demanding and as such there are challenges in completing the syllabus. About 7% complained that their teacher was often away on other school commitments and they therefore missed out on mathematics classes; 11% of students thought that their teacher did not explain the mathematical concepts clearly and there was no individual attention given by the teacher, even though the mathematics teachers in this study were considered to be highly qualified (Coetzee, 2009: 32-33).

In addition, the findings signify that supplementary tuition offered in the participating schools is generally of three forms, which are private tuition, vacation school, and problem-solving classes. It turns out that problem solving classes, which were mainly dominated by the revision of past/model examination papers, was the most preferred form (about 83%), followed closely by private tuition at 81% and lastly vacation school at 38%.

According to Coetzee (2008), South African parents spend on average about 5% of their income on additional support programmes, especially for mathematics tuition. Bray (1999) and Reddy (2003; 2005) have shown that South African parents from low socio-economic income groups accorded education such importance that they were prepared to make financial sacrifices to improve their children's mathematics achievements at school.

A study undertaken in 2001 showed that more than 75% of Grade 8 students in South Africa receive supplementary tuition in mathematics largely because of poor mathematics teaching and learning at government schools (Centre for Development and Enterprise, 2013:1-2). Several of the provincial education departments have introduced supplementary teaching programmes. For instance, the Gauteng Education Department (2013) showed that the Secondary School Improvement Programme (SSIP, 2010) was implemented to provide supplementary tuition for mathematics students in Grades 8 to 12 at 438 high schools in the

province. Classes were held over weekends and during the holidays, with residential and walk-in examination revision camps for Grade 12 students. Grade 10 and 11 students received examination preparation support during the October holidays.

Furthermore, many students make use of supplementary tuition programmes offered privately by non-profit organisations; school mathematics teachers; specialist extra mathematics tuition franchise companies such as Master Maths, Kip McGrath and Kumon; extra mathematics schools such as Maths Tutor; extra mathematics revision programmes offered by certain universities during the school holidays; and specialist education support services such as Brombacher and Associates (Centre for Development and Enterprise, 2013: 4). However, the criticism that is levelled at most of these supplementary tuition programmes is that they are costly, and therefore generally accessible only to those who can afford them (Reddy, 2005).

3.4.1.2 International studies on student support

International mathematics studies, such as TIMSS (Howie, 1999), PISA (OECD, 2001) and SACMEQ II (Moloi, 2000), highlight the high performance in mathematics by students in many Asian countries, especially Japan. This could in part be contributed to by the extent to which supplementary tuition is used. Normal teacher-oriented lessons that focus on imparting mathematical content knowledge are given during the day and in the afternoon; students are subjected to supplementary tuition that is dominated by problem solving (Howie, 1999).

In Malaysia, 83% of students participate in supplementary mathematics programmes. In Egypt, 74% of Grade 8 students receive tutoring. In Mauritius 100% of students in form five and six were receiving extramural tutoring in the nineties. Even in European countries like Germany, where the prevalence of supplementary tuition is relatively low, extra tuition in mathematics seems to be the most sought after, and between 16% and 20% of children receive extra tuition (Mischo & Haag, 2002). Studies conducted by Posner and Vandell (1999) and MacBeath, Kirwan, Myers, McCall, Smith and McKay (2001) have found structured after-school programmes in Great Britain to be particularly beneficial to students from disadvantaged backgrounds.

In an international study, Lee (2002) reports that in Asian countries such as Japan and Korea, parents' support for mathematics education involves considerable financial support for additional mathematics support programmes. Parents from these countries, including those

from underprivileged backgrounds, are willing to spend more than 25% of their income on mathematics tuition support programmes. According to Lee (2002), in Korea more money is spent by parents on supplementary tuition than what the government spends on formal education. Typically, countries like Japan, Singapore and Korea have not only seen their students performing well in cross-national and comparative studies such as the TIMSS study, but these countries are also rapidly progressing technologically.

What is prevalent in the above studies is the level of importance that is ascribed to supplementary tuition. One common reason arises, and that is that supplementary tuition is regarded by parents as a necessity for success in mathematics and for socio-economic advancement (Baker et al., 2001; Bray, 1999). However, according to Ireson (2004: 120), supplementary tuition has the potential to distort the education system by “conferring significant disadvantages on those who are unable to afford the cost of tutors”, especially those students from disadvantaged socio-economic backgrounds.

3.4.2 Support for mathematics teachers

3.4.2.1 South African studies on teacher support

The Department of Basic Education has implemented various policies to address some of the root causes of under-performance in mathematics education in general. The Curriculum and Assessment Policy Statement (CAPS), the Action Plan to 2030, and the implementation of the Annual National Assessments (ANAs) are but a few. The CAPS policy document proposes making mathematics and science more practical subjects by including more assessments. Mathematics, being a practical subject, requires more assessment exercises to help gauge the students’ level of understanding. This helps teachers to focus on the aspects with which students have difficulty grasping.

One of the intentions behind the ANAs is to allow teachers to be involved in the marking of tests in order to facilitate teacher training, and the exposure of teachers to better assessment and marking practices. Scripts from a sample of schools are sent to the HSRC, which oversees the re-marking of all scripts in a highly controlled environment. Teachers from schools considered as being good at the assessment of students are selected to perform the re-marking. Close attention is given towards ensuring that sufficient numbers of teachers with competencies in each of the official languages are recruited, given the use of all the official languages in the tests. However, there are several limitations with the implementation and

evaluation of the ANAs. They are too prescriptive and do not allow teachers to be flexible, thus preventing them from integrating the various specific aims within a single assessment task (Catholic Institute of Education, 2010). There are several other limitations:

1. Problems exist with the formulation and translation of certain questions.
2. Most of the responsibility for the correct administration of the ANA tests was placed in the hands of school principals. This is the procedure followed in schools participating in the NSC (Grade 12) examinations. This points to a need for better training of school principals in future, instructions that are in certain respects clearer and stronger external control.
3. Individual school average results will be well above or below what they should be, due to poor marking practices by teachers.

In 2001, the national Department of Education introduced the Dinaledi Schools Project to provide support in the form of physical resources and professional development programmes to equip teachers with the necessary pedagogical and content skills to improve the science and mathematical results within a few selected schools. The strategy involved selecting certain secondary schools that had demonstrated a potential for increasing learner participation and performance in mathematics and science and providing them with the resources and support to improve the teaching and learning of these subjects. The schools selected offered mathematics and science in the higher grade and had small class sizes and competent mathematics and science teachers. The programme started with 102 schools in 2002 to 2004, and by 2008 this number had increased to a (capped) total of 500 (8% of secondary schools) (Department of Education, 2009: 6).

Several evaluations of the Dinaledi Project were made. In 2009, the Department of Basic Education claimed that the programme had succeeded in reaching its target of increasing the number of matriculants with a high pass in mathematics to 50 000 in 2008, with Dinaledi schools having exceeded their target of 10 000 passes of 50% or more by 5 051. The performance in 2008 showed that 268 out of 500 Dinaledi schools produced 50 or more students passing mathematics and 76 produced more than 100 students who passed mathematics. Seventeen Dinaledi schools produced fewer than 10 students passing mathematics, 38 produced between 11 and 20, and 177 produced between 21 and 50 passes. Dinaledi schools, which had a target of 60:40 enrolment for mathematics compared to

mathematical literacy, reached the ratio of 2:1 students taking mathematics compared to mathematical literacy in Grades 10 and 11, and 5:1 in Grade 12 in 2008 (Department of Education, 2009: 11-13). Furthermore, in an evaluation of the programme by the World Bank, it was found that between 2005 and 2007, there was an increase in the number of students passing mathematics in the Higher Grade in Dinaledi schools (Blum Krishnan & Legovini, 2010). In 2008 a 100-hour teacher training process was undertaken with 2 400 teachers in Dinaledi schools across all nine provinces to strengthen their content knowledge, improve their teaching of mathematics and science and improve learner performance. In order to ensure that teachers at Dinaledi schools are well supported, the national Department of Basic Education subject specialists in mathematics and science conducted a series of workshops for heads of department for mathematics, science and technology in Dinaledi schools in August and September 2008. The training focused on principles and methods of good classroom practice, and their roles and responsibilities in curriculum management and assessment. In 2009 the quality of mathematics and science teaching at Dinaledi schools were further strengthened through an audit of the qualifications of the mathematics and science teachers. This enabled the Department of Education (DoE) to establish the teacher: learner ratio in Dinaledi schools with a view to establish class size and finding high performing schools that have the capacity to expand enrolment.

One major disadvantage of the implementation of the Dinaledi Schools project was that it has led to some unevenness, with procedures for adding or excluding schools not being applied uniformly across provinces. For example, some provinces de-listed schools that had not significantly improved their output of mathematics and science students, whereas others have retained schools with low Higher Grade enrolments. In some cases, schools were not allocated sufficient mathematics teachers and learning materials and some provinces had too few curriculum advisors to support the Dinaledi schools in their provinces.

Programmes such as the National Professional Diploma in Education (NPDE) and the Advanced Certificate in Education (ACE) provide support for practising teachers to upgrade their qualifications. In a recent study, Bansilal et al. (2014) investigated the subject content knowledge of mathematics teachers studying towards an Advanced Certificate in Education (ACE) at the University of KwaZulu-Natal (UKZN). When these Grade 12 teachers, studying towards an ACE were tested on a shortened version of a Grade 12 mathematics paper, it was found that on average teachers obtained 29% for questions that were at the problem-solving

level. This raises questions about how these practising teachers could mediate tasks set at high cognitive levels for their Grade 12 students. These findings suggest that there is a need for better and improved pre-service training, and relevant and effective in-service training for mathematics teachers.

In an attempt to improve the pedagogical and content knowledge of mathematics teachers at five previously disadvantaged high schools in the Western Cape, the Mathematics and Science Education Project (MSEP), a joint collaboration between the University of Cape Town and the Western Cape Education Department, provided teachers at these schools' scholarships and professional developments in mathematics through certified short courses. However, there has been no attempt to reveal the actual mathematics performance of the students at these schools, especially of mathematics students in Grade 12, and to directly relate teacher improved mathematical skills and qualifications to the outcomes of the study. However, 238 students at the five schools gained entry at five institutions of higher learning between 2010 and 2013 (Makgaka, 2016).

The African Institute for Mathematical Sciences Schools Enrichment Centre (AIMSSEC) was established in 2003. This initiative is facilitated by a distinguished team of more than 50 international expert mathematics education volunteers on the residential courses and support local staff and students, with the aim of introducing new skills to mathematics teachers in disadvantaged communities across primary and high schools in South Africa (UNESCO, 2012). To spread the benefits of this work more widely, AIMSSEC conducted professional development courses for 57 teachers from disadvantaged rural and township schools from four provinces (Limpopo, KwaZulu Natal, Eastern Cape and Western Cape) and empowers them to train other teachers in their areas. AIMSSEC offers blended learning courses for primary and secondary teachers, curriculum advisers and field trainers from all over South Africa. It combines residential units, home study, regularly marked assignments, online learning and TV broadcasts, and examinations for qualifications jointly offered by AIMSSEC and the Universities of Stellenbosch and Fort Hare. Since its inception in January 2014, a total of 1 240 teachers have taken the AIMSSEC three-month Mathematical Thinking (MT) course. This course, offered by Rhodes University in the Eastern Cape, acts as a prerequisite for the two-year AIMSSEC Advanced Certificate in Education (ACE) course, which has a focus on subject leader training and currently has 144 graduates.

Although the project is still in its infant stage, and to make evaluations will be difficult at this stage, one debilitating factor that might hinder the success of such a project is that the AIMSSEC project requires all teachers to have access to the internet. This poses a challenge to mathematics teachers from rural and previously disadvantaged schools that lack the necessary technological resources (AIMSSEC, 2013).

3.4.2.2 International studies of teacher support

The Partnership for Access to Higher Mathematics (PATH1995) in the United States conducted studies of 102 at-risk eighth graders from both Hispanic and white backgrounds, with the intention of improving curriculum and instruction (Dossey, McCrone & Halvorsen, 2016). The focus of this study was to provide mathematics teachers at these schools with a variety of programmes intended to enhance mathematics achievement. These programmes included mathematics textbooks, computer-assisted instruction programmes, and programmes intended to enhance professional development for mathematics teachers. The latter included programmes focusing on cooperative learning, individualised instructions, mastery learning, and programmes explicitly focused on mathematics content, with the focus on improving curriculum and instruction.

The study revealed that, irrespective of socio-economic backgrounds, the provision of a variety of mathematics textbooks did not have a significant impact on mathematics student performance. Mathematics computer-assisted instruction programmes did, however, have a measure of impact on mathematics performance. The most striking conclusion was that instructional practices, such as cooperative learning in mathematics, had strong impacts on overall mathematics performance. The outcome of this study strongly supports the context of the current study, as it emphasises the importance of interconnectedness within the different environments of learning.

3.5 CONCLUSION

Mathematics schooling remains a key factor for employment opportunities in South Africa and in any other part of the working world. For South Africa to succeed in the global economy, it is partly dependent on achieving high levels of performance in mathematics and numeracy. This is currently not the situation in South Africa. The reality is that South African mathematics students perform poorly in mathematics in comparison to the rest of the world. Mathematics pass rates in South Africa are a major concern, which emphasises the need for support for

mathematics teachers and students. Another concern relates to the quality of the mathematics passes coupled with the observable differences between the number of enrolments for mathematical literacy and pure mathematics. The latter is regarded as being more important to those students who require access to tertiary qualifications in fields such as engineering, business and science, with the focus on abstract and hypothetical thinking.

The current study differs from the studies discussed in this chapter by conducting a comprehensive investigation to determine the challenges in mathematics teaching and learning at disadvantaged high schools in Cape Town. The current study anticipated: to identify the support that are available for the mathematics teachers and students at the schools included in this study; to identify the extent to which teachers and students utilise these opportunities; and to highlight factors that enable or limit access to and utilisation of these mathematics support opportunities. Furthermore, this study, unlike some of the previous studies, also attempted to identify the strengths and limitations of the available mathematics support opportunities. It was anticipated that the findings of this study would be able to identify general gaps in the support system that must be addressed, aspects that might need to be strengthened, as well as the appropriate mathematics support in specific circumstances.

CHAPTER 4

METHODOLOGY AND RESEARCH DESIGN

4.1 INTRODUCTION

This chapter delineates the methodology and research design for the study. The research undertaken in this study sought to identify the challenges in mathematics teaching and learning at selected previously disadvantaged Cape Town high schools, and to determine the appropriate support for mathematics teachers and students at these schools. Such objectives are necessary because of poor mathematics performance at the NSC level in South Africa, and the international recognition that support opportunities for mathematics teachers and students are vital for success in mathematics education.

Hitchcock and Hughes (1995: 21) suggest that ontological assumptions, that is one's view of reality, give rise to epistemological assumptions, that is how one acquires knowledge. These, in turn, give rise to methodological considerations, which in turn give rise to issues of instrumentation and data collection. Thus, in developing the methodology used for this research, the process began with a review of the relevant philosophical perspectives. This was followed by a review of research strategies relevant to the philosophical perspectives that underpin the methodology chosen, with a focus on the case study as the most appropriate strategy of enquiry; followed by a discussion of the instruments for data collection; and concluded with methods of data analysis. The starting point was to set out the foundations and justification of the empirical and ontological perspectives on which this study is constructed.

4.2. PHILOSOPHICAL PERSPECTIVES

A paradigm is a comprehensive belief system, world view, or framework that guides research and practice in a field (Taylor & Medina, 2013). All research undertaken needs a foundation for its enquiry, and researchers need to be aware of the implicit worldview, the status of human knowledge and the methods that can be used to answer research questions based on human phenomena. Tashakkori and Teddlie (2010) state that differing worldviews can and should coexist, as they offer healthy contrasts and diversified dialogues. Table 4.1 presents

the different worldviews and describes the characteristics of the philosophical assumptions under each view.

Table 4.1: Different research paradigms

Paradigm	Ontology	Epistemology	Question	Method
Critical theory	Society is rife with inequalities and injustice	Helping uncover injustice and empowering citizens	How can I change the situation?	Ideological review, civil actions
Pragmatism	Truth is what is useful	The best method is one that solves problems	Will this intervention improve learning?	Mixed-methods, design-based
Constructivism/ Interpretivism	Reality is created by individuals in groups	Discover the underlying meaning of events and activities	Why do you act this way?	Qualitative
Positivism	Hidden rules govern teaching and learning process	Focus on reliable and valid tools to uncover rules	What works?	Quantitative

Source: Table adapted from various sources, including Crotty (1998).

4.2.1 Critical theory

Jurgen Habermas can be considered the main protagonist of critical theory. Habermas focused on developing an approach of investigation and action in the social sciences, which could describe the historical forces that restrict human freedom and expose the ideological justification of those forces (Dash, 2005). Theorists like Habermas were critical of the earlier paradigms as they were not tuned to question or transform the existing situation. He developed theories which were built on a typology of interest. Habermas (1970) postulated three areas of interest which generate three types of knowledge:

- A technical interest concerned with the control of the physical environment, which generates empirical and analytical knowledge.
- A practical interest concerned with understanding the meaning of situation, which generates hermeneutic and historical knowledge.

- An emancipating interest concerned with the provision for growth and advancement, which generates critical knowledge and is concerned with exposing conditions of constraints and domination.

Critical theorists suggest two kinds of research methodologies, namely ideology critique and action research, for undertaking research work. Critical theory has been criticised by some contemporary scholars. Lakomski (1999) questions the acceptability of the consensus theory of truth on which Habermas's work is premised. Habermas's work is little more than speculation. Whilst the claim to there being three forms of knowledge has the epistemological attraction of simplicity, one has to question this very simplicity (Keat, 1981); there are a multitude of interests and ways of understanding the world, and it is simply artificial to reduce these to three interests (Cohen, Lawrence & Morrison, 2000). This paradigm is thus inadequate for this study.

4.2.2 Pragmatism

Pragmatism can be considered a bridge between a paradigm and methodology. In its simplest sense it can be referred to as a practical approach to a problem and has strong associations with mixed-methods research (Cameron, 2011). It is orientated towards solving practical problems in the real world (Feilzer, 2010), with its main focus on the 'how' of the research problem (Creswell, Clark, Gutman & Hanson, 2003). Although it may be said that pragmatism fails to give a coherent rationale for mixed-methods due to its lack of a clear definition of what works and clearly defining goals, it does, however, place the research problem as central and applies all approaches to understanding the problem (Creswell et al., 2003). It may well be understood by researchers that mixed-methods could be used with any paradigm.

Pragmatism has reached a wider recognition and acceptance by social and human science researchers to enrich and strengthen educational research through the application of qualitative and quantitative methods in complementary ways (Biggerstaff, Jhung, Kamimoto, Balluz & Finelli, 2012). Furthermore, pragmatism as a paradigm was shown to give credence to widely varying aspects of human experiences. Experience is a process through which we interact with our surroundings, obtaining information that helps us to meet our needs. Dewey (1938), like Peirce (1966; 1998), thought that experiences were full of inferences. Similarly, James (1907) announced that 'the relations between things, conjunctive as well as disjunctive, are just as much matters of direct experience, neither more nor less so, than the things themselves.' In this study, it was considered imperative to investigate the relations and

experiences of all stakeholders (mathematics teacher, mathematics student, parents, mathematics curriculum advisors and the wider community) in order to answer the research questions of the study.

Furthermore, quantitative and qualitative methods were employed to produce a more complete picture by combining information from the quantitative data (survey) with the qualitative data (interviews) in a complementary way. According to Johnson, Onwuegbuzie and Turner (2007), complementarity involves seeking elaboration, illustration, enhancement or clarification of findings from one method using results from the other. This was indeed the purpose of utilising a mix-methods approach in this study

4.2.3 The constructivist/ interpretivist viewpoint

Constructivism rejects the view that human behaviour is passive, controlled and determined by the external environment. The basic premise of constructivism is that truth and meaning do not exist in some external world but are created by the subject's interaction with the world. In other words, meaning arises from the process of social interaction. Mason and Smith (2000) affirm this view, signifying that meaning is constructed by individuals as they engage with the world. Their interpretations and the way they make sense of the world are based on their historical, cultural and social perspectives. As elaborated by Crotty (1998), the social environment is thus seen as an extension of the experiences of the individual. Two of the main purposes of this study were to identify the challenges in mathematics teaching and learning at the schools under study, and to determine the appropriate support opportunities for mathematics teachers and students at these schools. The participants in this study construct meaning of how these mathematics support opportunities enhance their understanding of the teaching and learning of mathematics, and more importantly, how they improves students' academic performance.

While interpretivism centres on the study of social phenomena that requires understanding of the social world that people live in (Bada & Olusegun, 2015), emphasising experience and interpreting how *society* understands a given situation, constructivism focuses on the ways the *researcher* 'constructs' meaning to these experiences. Constructivist research focuses upon the ways that the speaker/ writer makes the text, i.e., meanings made from their point of view as writer/ speaker. Interpretivist research focuses upon the meanings by those other

than the writer/ speaker. A theoretical perspective linked to constructivism is interpretivism. In general, an interpretivist approach is built on the following beliefs:

- Relativist ontology– Reality is perceived as being intersubjective. Its foundations are embedded in meanings and understandings at social and experiential levels, existing between conscious minds.
- Transactional or subjectivist epistemology – People are inseparable from their knowledge, indicating a clear link between the researcher and the research subject (Thomas, 2010).

Sikes (2004: 21) explains that if knowledge ‘is assumed to be experiential, personal and subjective’, researchers ‘will have to ask questions of the people involved’. In this study, the research design and choice of procedures are based on the assumption that some important aspects of the requisite knowledge are experiential, personal and subjective. Certain aspects of the research are thus constructed within an interpretivist paradigm. One of the characteristics of the interpretive approach is that findings emerge through naturalistic methods such as interviews, where qualitative methods are used. Furthermore, the interpretivist approach also focuses on negotiating the truth through dialogue with the wider community in order to construct a meaningful reality. In this study, interviews were conducted with the mathematics community – that is, within the educational sphere of the school, which constitutes the mathematics students, mathematics teachers, and officials of the Western Cape Education Department responsible for providing support for mathematics education at schools in the Cape Flats, in order to identify and establish the types of mathematics support rendered to the mathematics students and teachers.

The epistemological premise informing the research in this study was that all participants are mindful of some of the challenges they face in mathematics teaching and learning, and the most appropriate support opportunities to improve student performance. Each participant in this study constructed their own meaning of the challenges and the most appropriate support programme. The constructivist/ interpretivist viewpoint that underpins this study sets the basis for some aspects of the research design.

4.2.4 Positivism

The positivist paradigm of exploring social reality is based on the philosophical ideas of the French philosopher August Comte, who emphasised observation and reason as means of

understanding human behaviour. According to Comte, true knowledge is based on experience of senses and can be obtained by observation and experiment. Positivistic thinkers adopt his scientific method as a means of knowledge generation (Thomas, 2010). Therefore, it has to be understood within the framework of the principles and assumptions of science. These assumptions, as Cohen et al. (2000) noted, are determinism, empiricism, parsimony, and generality.

‘Determinism’ means that events are caused by other circumstances and hence, understanding such causal links is necessary for prediction and control. ‘Empiricism’ means collection of verifiable empirical evidences in support of theories or hypotheses. ‘Parsimony’ refers to the explanation of the phenomena in the most economical way possible. ‘Generality’ is the process of generalising the observation of the particular phenomenon to the world at large. With these assumptions, the ultimate goal of science is to integrate and systematise findings into a meaningful pattern or theory which is regarded as tentative and not the ultimate truth. Theory is subject to revision or modification as new evidence is found. The positivistic paradigm thus systematises the knowledge generation process with the help of quantification, which is essential to enhance precision in the description of parameters and discernment of the relationship among them.

Positivism, which emphasises an objectivist approach to studying social phenomena, gives importance to research methods focusing on quantitative analysis, surveys, experiments and the like. This study sought to identify the link between performance in mathematics to certain forms of parental support for mathematics students. The study thus employed research methods associated with positivism, and the research design and choice of procedures for parts of the study assumes that ‘knowledge is real, objective and out there in the world to be captured’, and therefore ‘researchers can observe, measure and quantify it’ (Sikes, 2004: 21). A survey was conducted with students at the schools under study to determine perceived parental aspirations, support and influence.

This study thus makes use of both qualitative and quantitative research methods. The type of evidence collected to answer the research questions can either be quantitative or qualitative, or a combination of both. Quantitative research produces results derived from statistics, whereas qualitative research data do not yield easily to automatic or technical analysis. This understanding of quantitative research aligns closely with the views of the positivist paradigm

discussed above. Positivism which emphasises an objectivist approach to studying social phenomena (UK Essays, 2013) adheres to the view that only “factual” knowledge gained through observation (the senses), including measurement, is trustworthy. In positivism studies, the role of the researcher is limited to data collection and interpretation, and the research findings are usually observable and quantifiable (Kamath, 2014).

In qualitative research the meaning of the data is not immediately obvious. Rationality is needed to extract meaning from data (Eisner, 1997). According to Strauss and Corbin (1998), qualitative research pursues a deeper understanding of human experience; with the focus on aspects of human behaviour in order to explain, predict, describe and control behaviour. This understanding of qualitative research aligns closely with the views of the constructivist/ interpretivist paradigm discussed in the preceding sections.

4.3 RESEARCH DESIGN

4.3.1 Introduction

De Vaus (2006) refers to research design as the overall strategy to integrate the different components of the study in a coherent and logical way to effectively address the research problem. It constitutes the blueprint for the collection, measurement and analysis of data. Yin (2011), however, cautions that the research design should be ‘logical’, where logic involves the link between the research questions, the data to be collected, and strategies for analysing the data so that the findings can address the intended research questions. The overall research design for this study is exploratory will be demonstrated in the next section. It is situated within both the constructivist/ interpretivist and positivist paradigms. The research methods selected for this study were one-on-one interviews, focus group interviews and surveys. The type of research design selected is the case study.

Data collection is the systematic approach of gathering and measuring information from study participants to answer related research questions to a research problem, to evaluate outcomes and make predictions on future probabilities and trends (Castagna & Yao, 2016). Therefore, data collection is considered an important aspect of any type of a research study. According to Cohen, Budnitz, Weidenbach, Jernigan, Schroeder and Shehab (2008), there is no single prescription for specific data collection instruments to be used. The choice should be ‘fitness for purpose’, that is, the purpose of the study will influence the selection and choice

of data collection instruments. In this study, both qualitative and quantitative research data-collection methods were utilised. This is referred to as a mixed methods research approach to research. The reason for using this approach is that qualitative and quantitative research, in combination, could provide a better understanding of a research problem than each research approach alone. Creswell et al. (2003) refer to three general strategies when using the mixed methods research approach:

- Sequential procedure – in which the researcher seeks to elaborate on the findings of one method with another method.
- Concurrent procedure – the researcher converges quantitative and qualitative data to provide a comprehensive analysis of the research problem.
- Transformative procedure – the researcher uses an overarching perspective within a design that contains both qualitative and quantitative data. The researcher may use a combination that involves both a sequential and a concurrent approach.

The qualitative and quantitative data were collected for a better integration and corroboration of information in the interpretation of the overall results, indicating the use of a concurrent procedure. Johnson et al. (2007) renamed the three general strategies of the mixed-method approach of Creswell et al. (2003) as qualitative-dominant, pure mixed and quantitative-dominant. In this study, a qualitative-dominant strategy was used with the bulk of the data collection instruments and the consequent data being qualitative in nature. Clark (2007) on the other hand, proposes four main research design types of the mixed-method approach, with multiple variants:

- the triangulated design, to obtain different but complementary data;
- the embedded design, in which one data set provides a supportive secondary role;
- the two-phase explanatory design, which builds on or explains quantitative results; and
- the exploratory design, which is also two-phased but led by the qualitative.

This study makes use of the embedded design, in which the quantitative data provides a secondary supportive role to the qualitative data. This is also referred to as the sequential exploratory mixed method design. This method has a two-phase design. Qualitative data is collected first, followed by the collection and analyses of the quantitative data. This is done to serve as a classification for testing or even enhancing the qualitative data (Centre for Innovation in Research and Teaching, 2019), which is the case in this study. The strengths of the mixed methods research approach assisted the researcher in gaining deeper insights into

the nature of the challenges and support for mathematics students and mathematics teachers at the GET and FET levels.

4.3.2 Case studies

Crowe, Creswell, Robertson, Huby, Avery and Sheikh (2011) state that the case study approach allows for an in-depth, multi-faceted exploration of complex issues in their real-life settings. The case study approach is particularly useful to employ when there is a need to obtain an in-depth appreciation of an issue, event or phenomenon of interest in its natural real-life context.

Starman (2013) argues that the interpretative paradigm, phenomenological approach, philosophical perspectives and constructivism as paradigmatic bases of qualitative research are closely linked to the definition and characteristics of case studies. However, the relevance of the case study research design for this study is also found in Yin's (1993: 32) belief in the irrelevance of the quantitative/ qualitative distinction for case studies. This authority on case study design points out that:

. . . a point of confusion . . . has been the unfortunate linking between the case study method and certain types of data collection, for example, those focusing on qualitative methods, ethnography, or participant observation. People have thought that the case study method required them to embrace these data collection methods . . . On the contrary, the method does not imply any particular form of data collection which can be qualitative or quantitative.

Atkins and Wallace (2012) state that a case study has the ability to go beyond the 'how' and 'why' questions: it offers a way of investigating connections, patterns and context, and of reflecting on the details and the bigger picture under investigation. Hence, the case study provides a comprehensive description of an individual case and its analysis, i.e. the characterisation of the case and the events, as well as a description of the discovery process of these features (Mesec, 1998). Although a case study is more qualitative than quantitative in nature, each approach to data collection can be represented equally, complementing each other to create a meaningful result according to the object and purpose of the investigation (Sagadin, 2004). A key strength of the case study design is that it can make use of multiple sources and data collection techniques, such as surveys and interviews in the data-gathering process. The researchers are thus able to determine in advance what evidence to gather and

what analysis techniques to use with the data to answer the research questions. Table 4.2 highlights the advantages and limitations of utilising a case study in the context of this study.

Table 4.2: The advantages and limitations of using a case study in the context of this study

Advantages	Context of this study
Is applicable to complex real-life situations Favours data collection in a natural setting Robust research method	The challenges of mathematics teaching and learning Interviews conducted in mathematics teaching and learning environment. Holistic, in- depth investigation is required; interviews with students, mathematics teachers, departmental officials responsible for mathematics support to schools
Limitations	
Lack of generalisability	Limited to selected high schools in previously disadvantaged areas in Cape Town
Time-consuming	Due to multiple data collection techniques, (surveys, interviews) a lot of data to analyse
Generates qualitative data	Meaning may become subjective (researcher bias)

Guba and Lincoln (1981) describe three types of case studies: factual, interpretative and evaluative. Walsham (2002) refers to interpretative studies as providing data of thick descriptions, not reporting any facts but rather the researcher’s interpretation of other people’s perceptions’ not aiming to produce “truth” but still generalisable findings. Similar to interpretative case studies, the main aim of evaluative case studies is to obtain as full an understanding as possible of a situation gained by extensive description and analysis of the situation. The focus of an evaluative case study is to obtain a comprehensive understanding of those extensive descriptions as a whole and within its context (Leo, 2013).

Factual case studies, although similar to evaluative and interpretative case studies in the broad sense that they provide a wealth of details about a situation, do however furnish concrete and not theoretical solutions as a means of giving credibility to situations and problems (Warner, 2018). This study can be classified as both factual and interpretative. The audio recordings, together with the focus group sessions and the surveys serve as a basis for providing a comprehensive understanding of the situation within its context. This is done in an effort to answer the research question in Section 1.6. In addition, information was analysed, construed and clarified, producing in depth understanding of the research problem.

Mariano (1993) proposes that the purposes of case study research may be exploratory, descriptive and explanatory. A descriptive case study design presents an in-depth description of a phenomenon within its context. Exploratory and descriptive case study designs can involve theory generation, while the explanatory case study design is appropriate for theory testing (studies that assess the validity of single or competing theories). This study is considered a descriptive case study as it provides a comprehensive and in-depth understanding of the situation, namely the challenges of mathematics education within the different contexts in which teaching and learning takes place. Stake (1995) proposes three types of case studies:

- Intrinsic case study is used to understand the particulars of a single case, with the focus on the case being of the highest importance.
- Collective instrumental case study is when the researcher collects data from different sources such as schools and individuals. More than one case can be simultaneously studied, with each studied in its holistic entirety.
- Instrumental case study is used to examine a pattern of behaviour, to provide insight into an issue, with the focus on the issue being of the highest importance.

This study is firmly substantiated as collective instrumental with its focus on mathematics students', mathematics teachers', and mathematics curriculum advisors' collective understanding of their experiences of mathematics teaching and learning at five high schools in the Cape Flats area. Unlike intrinsic case studies, which set out to solve the specific problems of an individual case, instrumental and collective case studies may allow for the generalisation of findings to a bigger population (Zainal, 2007). This study goes beyond the self-interest to incorporate the insights gained to understand the phenomenon at a level that would be of significance to all stakeholders involved with mathematics teaching and learning. Furthermore, insights gleaned from this case study can directly influence policy, procedures and future research (Merriam, 2009).

4.3.3 Population of the study and sampling procedures

According to Babbie and Mouton (2002), sampling in social sciences research refers to procedures which produce a representative selection of population elements. For this study, the population was the high schools in the Cape Flats area of the Cape Metropole, from which a sample of five schools was selected using a purposive sampling procedure. According to

Garfield Blake, Chatainger and Walton-Ellery (2011), purposive sampling provides a sample where the identified group is selected according to specific characteristics that can be considered important to the study. In identifying such a sample, group differences can be compared and contrasted. Patton (2002) notes that the power of purposeful sampling lies in selecting information-rich cases, that is, participants who will provide knowledge and expertise according to the needs of the study. The study focused on five high schools (Grades 8 to 12) in the Cape Flats area of the Cape Town Metropole. This number accounted for 17% of the high schools in the area, which is a rational representative sample that generated the data necessary to answer the research questions. The five high schools were purposively selected from the 30 high schools in the selected Cape Flats area because of the common socio-economic background of the areas in which they are located and, more importantly, because they are among the few schools in the area that offer pure mathematics at the FET level. The schools selected for the study fall under two of the eight education districts in Cape Town. They are Metropole South and Metropole North. These education districts were included based on the selection of the five schools. Two curriculum advisors from each district were purposively selected from a list of curriculum advisors obtained from the Western Cape Education Department. The selected curriculum advisors were responsible for support to mathematics teachers at the GET and FET level, and were responsible for support to teachers of mathematical literacy and pure mathematics. A list of all the mathematics teachers (Grades 8 to 12) was obtained from each school. Specifically, purposive sampling was used in selecting two mathematics teachers from each phase, that is GET and FET, in each of the five schools. This means that two Grade 8 to Grade 10 mathematics teachers and two Grade 11 and Grade 12 mathematics teachers were selected to participate in the study. They were selected by virtue of the fact that they are teachers of mathematics at these schools, have spent several years (10 years or more) in the positions they hold, and have a broad understanding of the conditions at their schools.

In each of the five schools 20 Grade 12 students participated in the study. These were students who have taken pure mathematics up to Grade 12 level [On average, each of the schools had about 100 students taking mathematical literacy at Grade 12 level, with an average of 20 students taking pure mathematics]. The students selected were regarded as being in a position to provide pertinent information about the challenges that the school's mathematics students and possibly mathematics teachers face; and the support provided to them by

schools, the education department and external organisations. Grade 12 students, unlike students in the lower grades, would generally have spent several years at the school being taught mathematics in every grade at the school

On the whole, n=20 mathematics teachers, n=100 mathematics students in Grade 12 and n=5 curriculum advisors for mathematics and mathematical literacy in GET and FET. In the next section the purpose of each of the participating groups is outlined.

4.3.3.1 Curriculum advisors

Curriculum advisors were selected to participate in the interviews. During the interviews the curriculum advisors would be expected to provide information on their role in improving mathematics achievement in the schools in the districts in which they were assigned to provide educational support services at the time of conducting this study. In this regard educational support services would include providing advice about support for student and teacher support.

4.4 INSTRUMENTATION

The term instrumentation does not only focus on the choice of and naming of the data collection instruments, but it also refers to the entire process of developing the instruments and addressing the technical aspects such as reliability, validity and trustworthiness associated with data collections instruments.

4.4.1 Choice of and naming of data collection instruments

4.4.1.1 Semi-structured interviews

Semi-structured interviews were conducted with mathematics teachers and district officials of the Western Cape Education Department responsible for the provision of support services to mathematics teaching and learning at schools in the Cape Flats. Schostak (2006) defines an interview as an extendable conversation between partners that aims at arriving at 'in-depth information' about a certain topic or subject, and through which a phenomenon could be interpreted in terms of the meanings interviewees bring to it. Table 4.3 provides a summary of some of the advantages and disadvantages of using one-on-one interviews, also its applicability to this study is highlighted.

Table 4.3: Advantages and disadvantages of using one-on-one interviews in the context of this study

Advantage/ use of method	Disadvantage/ limitations of method	Implementation in the context of this study
Allows for more in-depth data collection; follow up questions can be asked.	Can be time consuming to conduct and analyse. As a result of timing and travel, it can be expensive.	<ul style="list-style-type: none"> • Information can be echoed and repeated to determine clarity and more comprehensive understanding. • Indicate the time frame prior to the interview and as much as possible adhere to the specified time frame. • Effective planning and implementation of the interview can limit timing and travel expenses.
Body language and facial expression can provide high credibility and face validity.	Interviews can deliver biased responses from the interviewee. Perceived status differences between the interviewer and interviewee.	<ul style="list-style-type: none"> • Incorporating active listening and good eye contact without judgement of the answers to the questions. • Establish rapport and trust by providing a relaxed, non-threatening and attentive approach.
The interviewer can probe for explanations of responses.	Probing for explanations and clarifications of responses can elicit a biased response from the interviewee.	<ul style="list-style-type: none"> • Descriptive questions tend to encourage interviewees to expand on their responses.
Stimulus and visual aids can be used to support and enhance the quality of the interview questions and the responses thereof.	Attention is paid to what is made visible and what remains hidden. This could possibly impose and evoke a particular way of thinking.	None specified.

Source: Adapted from Alshenqeeti (2014)

Babbie (2007) identifies three categories of interviews: structured interviews, semi-structured interviews and unstructured interviews. According to Ryan, Coughlan and Cronin (2009), structured interviews consist of closed ended questions that are structured in such a manner that the interviewer will not deviate from the interview or probe beyond the answers to the questions. The pre-determined questions allow for little or no variation and scant opportunity for follow-up questions (Gill, Stewart, Treasure & Chadwick, 2008). Although this interviewing technique is useful for reducing bias, its limitation is that it results in a lack of detail in terms of the complexity of the responses of the interviewee.

Semi-structured interviews, on the other hand, comprise several key questions that help to define the areas being explored, thus allowing the interviewer or interviewee to diverge in order to pursue a response in more detail. Such interviews are therefore more systematic and comprehensive in terms of the outline of the topics and issues to be covered, thereby

producing comparable qualitative data. This type of interview technique also allows for flexibility in terms of the time and scope of the participant's opinion on a particular subject. Willig (2001) states that using semi-structured, open-ended questions can lead to further discussion on different areas; setting out themes for exploration that is less biased. However, Keller (2010) cautions that it might be difficult to compare the results (due to the scope and flexibility), and therefore it can be problematic in making general comparisons.

Unstructured interviews do not reflect any preconceived ideas and provide little guidance on what to talk about. Such interviews are more flexible in the sense that questions can be adapted and changed, depending on the respondent's answers, and also allows for the making of clarifications by the interviewer. Since the interviewer does not ask exactly the same question(s) for each interviewee, it could be said that this method is less reliable and leads to results that may be more difficult to replicate (Cook & Cook, 2011). An interview schedule (Appendices E, F and G) was used to conduct the interviews. The questions for the interviews, including the focus group interview schedules with the 100 Grade 12 mathematics students at the five high schools, were based on the main research questions of this study. The interviews were guided by the interview schedule consisting of questions that were aimed at drawing responses from the participants with regard to the phenomenon under investigation.

Included in the interviews were questions that would provide insight into the mathematics students' interaction in and between the different environments, as well as how the interconnectedness of these environments potentially had an impact on the mathematics students' experiences of mathematics teaching and learning. The nature of the questions was aimed at identifying the challenges mathematics students and teachers encounter and to determine the type of support that impacts students' performance in mathematics. The environments or systems included were: the family (parents in particular), the mathematics students (the focal point of the systems), the school (mathematics teachers), and the wider community (education departments and private institutions). The one-on-one interviews were conducted at the participants' convenience in terms of venue and the allocated time-frame. In all instances, interviews were conducted at the schools under study and at the relevant district offices where the mathematics curriculum advisors are based. The participants were comfortable being interviewed in an environment which they were familiar with. On average, the interviews lasted between 60 and 90 minutes each. The interviews were conducted using the following guidelines, adapted from McNamara (2009):

- Participants were provided with a consent form to sign approving their participation in the research.
- Prior to the commencement of the research, participants were informed of the purpose and procedures of the study.
- Participants were thanked for the time and invaluable contribution to the research.
- The researcher offered information and introductory comments on the reason for the interview.
- Participants were informed and reminded of the use of the audio-recorder.
- The interviews commenced with the participants providing biographical background information.
- The researcher asked questions that transitioned between general and more complex (specific) questions.
- One question was asked at a time.
- The researcher attempted to remain as neutral as possible to the responses of the participants, and not to impose any particular viewpoint on the participants.
- The researcher encouraged responses with the use of verbal cues and body language (nodding, etc.).

At the end of the interview participants were thanked once again for the valuable input and were encouraged to ask any questions that would provide them with clarity on the possible outcomes of the research.

4.4.2 Purpose of each data collection instrument

The purpose of each data collection instrument is discussed in the next section.

4.4.2.1 Semi-structured interviews with teachers and curriculum advisors

Kvale (1996) notes that an interview is ‘a conversation, whose purpose is to gather descriptions of the [life-] world of the interviewee’ with respect to interpretation of the meanings of the ‘described phenomena’. In this study semi-structured interviews were opted for as a data eliciting source because it also made it possible to cover a range of issues relevant to the research questions and allowed for an open framework where the focus is on conversational two-way communication.

4.4.2.2 Students’ questionnaire

The survey questionnaires administered to the Grade 12 mathematics students were used to allow respondents to reflect on different questions related to the type of support the mathematics students receive from their parents. The data obtained from the questionnaire were nested with a larger qualitative data collection (interview data) to provide a comprehensive analysis of the problem, thus, indicating the use a concurrent procedure (Creswell et al., 2003), a qualitative-dominant design (Johnson, Onwuegbuzie & Turner, 2007), and an embedded design (Clark, 2007) in the research. Data collected from the questionnaire was primarily used to complement the qualitative part of this study.

4.4.3 The process of developing data collection instruments

4.4.3.1 Constructing items for students' survey questionnaire

Quantitative data for this study were collected using a survey questionnaire. The survey questionnaire was distributed to 100 Grade 12 mathematics students, 20 from each of the five participating schools. A five-point Likert scale response format was used. For each statement, the values of 5, 4, 3, 2, and 1 were assigned to the responses: "*Strongly Agree*" (SA), "*Agree*" (A), "*Undecided*" (UD), "*Disagree*" (D), and "*Strongly Disagree*" (SD), respectively. The questionnaire consisted of 10 items (see Appendix H).

The development of the questionnaire was based on the previous work of Cai (2003), and Poffenberger and Norton (1959). These studies explored the variable of parental influence using questionnaires. The students' perceptions of parental influence measured by the questionnaire in this study addressed two issues: direct involvement, including parents' assistance with homework and extra mathematics lessons; and indirect involvement, which was perceived to include parents' attitudes towards mathematics, encouragement, and expectations of student learning.

4.4.4 Ensuring reliability, validity and trustworthiness in the data collection process

4.4.4.1 Reliability and validity of quantitative data

Kvale (1989: 79) states that reliability is a question of whether repeated investigations of the same phenomenon will render the same result. Wilkinson (2000: 38) similarly describes reliability as relating to the consistency of the research instrument, for example, the likelihood of the same results being obtained if the procedure was repeated. In essence, it could be referred to as the repeatability of your measurement. Reliability was achieved in this study by

conducting interviews with more than one participant from the same school and conducting follow-up interviews to allow for clarification and verification of results.

Validity in quantitative research refers to the extent to which any measuring instrument measures what it is intended to measure (Thatcher, 2010). In quantitative research various different types of validity might be taken into consideration to motivate the relevance of the research instruments deployed. A survey questionnaire was designed to support the theoretical stance of this study. For the purpose of determining the validity of the research instrument (*survey questionnaires*), the examining of content validity appeared to be pertinent. Content validity requires the evaluation of each test item for its relevance to the intended construct (Yassir, McIntyre & Bearnm, 2016; Krikorian, 2016). The survey questions were designed to establish the type of support, mathematics students at the five high schools receive from their parents. To ascertain content validity the survey questionnaires can be reviewed by a panel of experts to solicit feedback on its effectiveness. (Lam, Hassan, Sulaiman & Kamarudin, 2018). The survey questions used in this study were reviewed by an expert researcher from the Human Sciences Research Council (HSRC).

4.4.4.2 Trustworthiness of Qualitative data

4.4.4.2.1 Credibility

Credibility in qualitative research denotes that the results of a qualitative study are believable and trustworthy from the perspective of a participant or subject in the research itself. Qualitative research attempts to describe or explain the event, group or phenomenon of interest from the perspective of participants who form the subjects of the study. As such, they are best situated to judge the credibility of the findings in a qualitative study (Shenton, 2004). According to Lincoln and Guba (1985), other techniques that promote credibility include making segments of the raw data available for others to analyse. Consequently, reliability is directly related to validity in the sense that credibility has been demonstrated. In this study credibility was achieved by conducting in-depth individual interviews and focus group interviews, audio recordings of the interviews and focus group interviews, and the use of direct quotations of participants' responses to preserve participants' meanings. Peer debriefing was also explored to allow an independent researcher to review raw data.

4.4.4.2.2 *Transferability*

Transferability is the generalisation of study findings to other situations and contexts. The context in which qualitative data collection occurs defines the data and contributes to interpretation of the data. Transferability can be enhanced by providing what is often referred to as *thick description*: giving enough detail for readers to decide for themselves if the results are transferable to their own contexts. Thick description involves a perspective which demands description that includes the actors' interpretations and other social and/or cultural information (Davis, 1995). In this study transferability was achieved by providing detailed contextual background information, as well as the careful selection of study participants to enhance optimal elicitation of desirable information for the research.

4.4.4.2.3 *Confirmability*

Confirmability, according to Trochim (2006), refers to the degree to which results can be confirmed or corroborated by others. There are a number of strategies for enhancing confirmability. The researcher can document the procedures for checking and rechecking the data throughout the study. Another researcher can play a devil's advocate role with respect to the results, and this process can be documented. The researcher can actively search for, and describe, any *negative instances* that contradict prior observations. After the study, a *data audit* that examines data collection and analysis procedures is conducted: it makes judgments about the potential for bias or distortion. In this study confirmability was achieved by documenting procedures for checking and rechecking the data throughout the study, as well as conducting a data audit after the data had been analysed and findings determined to identify any possible biases or distortions. This was achieved by comparing the findings with the transcripts, audio-recordings and completed survey forms.

4.4.4.2.4 *Dependability*

Dependability ensures that the research findings are consistent and could be repeated. This is measured by the standard at which the research is conducted, analysed and presented. Each process in the study should be reported in detail to enable an external researcher to repeat the inquiry and achieve similar results. Brown (1995) indicates that a major technique for assessing dependability is the *dependability audit* in which an independent auditor reviews the activities of the researcher as recorded in an audit trail in field notes, archives, and reports. The purpose of this audit is to test that the techniques for meeting the credibility and

transferability standards have been followed. If the researcher does not maintain any kind of audit trail, dependability cannot be assessed. In this study, dependability was achieved by initiating a debriefing process with an independent researcher on the research process, maintenance of audit trails, and including in the study a detailed description of the research steps taken from the start of the research to the reporting of findings, such as documents (support policies and programmes), transcripts of interviews, audio tapes of the interview, and hard copy of all raw data, included the completed surveys form

4.5 DATA COLLECTION PROCESS

Data collection is the systematic approach of gathering and measuring information from study participants to answer related research questions to a research problem, to evaluate outcomes and make predictions on future probabilities and trends (Castagna & Yao, 2016). Therefore, it is considered an important aspect of any type of a research study. According to Cohen et al. (2008), there is no single prescription for specific data collection instruments to be used. The choice should be 'fitness for purpose', that is, the purpose of the study will influence the selection and choice of data collection instruments. In this study, both qualitative and quantitative research data-collection methods were utilised.

4.5.1 Qualitative data

4.5.1.1 Focus group interviews

Focus group interviews were conducted with two groups of students, consisting of 10 students at each of the schools. Thus, a total of 100 mathematics students were selected to participate in the focus group sessions. According to Freitas, Oliveira, Jenkins and Popjoy (1998) focus group interviews are particularly suitable in research when the objective is to understand better how people consider an experience, idea or event. The discussion in focus group interviews in qualitative research is effective in supplying information about people's opinions or perceptions. Focus group interviews permit richness and flexibility in the collection of data that is not usually achieved when applying an instrument to an individual, while at the same time permitting interaction among the participants. In this study, focus group interviews were used to better understand the participants' perceptions of the challenges of mathematics teaching and learning and of support for mathematics education.

Goodman and Evans (2006) describe focus group interviews as open-ended discussions that address a predefined topic of interest to the group and researcher. Focus group interviews

allow the respondents to talk in some depth, thus also increasing the validity of the responses. According to Barbour and Schostak (2006), focus group interviewing is, “an interviewing technique in which participants are selected because they are a purposive, although not necessarily representative, sampling of a specific population, this group being ‘focused’ on a given topic”.

Focus group interviews could also allow for the clarification of misconceptions – respondents can repeat their answers to questions that may be rephrased if they were not clear. The researcher could process the information and produce a rapport with the group in a short space of time. In this study, the focus-group technique was used to obtain information from the Grade 12 mathematics students, which was difficult to obtain using other research methods such as one-on-one interviews due to time constraints imposed on the mathematics students at the respective schools.

There are several advantages and disadvantages of focus group interviews:

- Focus group interviews can be relatively inexpensive in terms of time and travel. The costs involved in planning, conducting and analysing data may be relatively small compared to alternative research methods, such as individual interviews.
- The researcher is able to probe issues in-depth and address additional issues as they arise.
- Participants might feel less intimidated and more comfortable when talking in a group in comparison to individual interviews.
- However, a problematic feature of focus group interviews is that the discussion and response of participants can be dominated and sidetracked by a few individuals within the group (U.S. Department of Health and Human Services, 2008).

Focus group interviews were held with two groups of students at each school, each group consisting of 10 students from Grade 12, a total of 20 students at each school, that is, 20 students who were taking pure mathematics up to a Grade12 level, aiming to determine: (1) the challenges that the school, mathematics students and mathematic teachers face; (2) the support in mathematics education that are available to them; (3) the support opportunities they access and utilise; and (4) the strengths and limitations of these support opportunities. The focus group interviews were approximately one hour long and were all audio recorded.

Since most of the participants shared the same classes from Grade 10 to Grade 12 as a result of all of them taking mathematics at the FET (Grades 10-12) level, this ensured effective group dynamics and eased the process of building sound relations, which usually occurs at the beginning of a focus-group interview. In addition, this also promoted frank and open discussions in which the respondents were able to add to others' views and opinions and also agree and disagree with one another (Curtis & Curtis, 2011).

According to Curtis and Curtis (2011), the role of the researcher, also referred to as a facilitator, is regarded as the core of the focus group interview. The researcher has to possess excellent communication skills and personal qualities that include being a good listener and being non-judgmental and adaptable to the responses of the participants within the group. The facilitator's key role is to encourage all the participants in a focus group to express their opinions with as little direction as possible (Yin, 2011). These qualities promote the participants' trust in the researcher, and increase the likelihood of open and interactive dialogue.

However, the researcher has to have a fair degree of control and direction and be consistent. It is thus crucial for the researcher to carefully prepare and plan roles and responsibilities when conducting focus group interviews. For example, in this study the researcher kept the participants focused on the questions by deliberately steering the discussion back on course and drawing out the participants' diverse range of meanings of the interview questions on the topic under discussion. In formulating questions for focus group interviews the researcher followed the guidelines proposed by Krueger and Casey (2000):

- The questions should be short and clear.
- The questions should be open-ended, requiring participants to elaborate on their responses.
- The questions should be one-dimensional; a question should ask one thing and not group things together that might be perceived as different. For example, asking if something is 'useful or practical' might lead to participants construing the two to be different.

The questions should sound conversational, using words that the participants would use in every-day situations.

The researcher formulated the focus group interview questions according to Bronfenbrenner's four ecological systems outlined in Chapter 2 (see Section 2.4). This included questions that would provide insight into the mathematics students' interaction in and between the different environments as well as how the interconnectedness of these environments potentially has an impact on the mathematics students' experiences of mathematics teaching and learning. The nature of the questions was aimed at identifying the challenges mathematics students and teachers encounter, and to determine the type of support that impacts students' mathematics performance. The environments or systems included were: the family (parents in particular), the school (teachers), and the wider community (education departments and private institutions). To achieve a successful interview, the researcher formulated the focus group interview questions by making use of five types of questions suitable for such interviews, as identified by Krueger (2000):

- Opening questions – these questions were related to what decisions contributed to taking mathematics at the FET level.
- Introductory experience and behaviour questions – these types of questions elicit responses that highlight participants' behaviour, actions and activities, for example, asking participants to talk about their general experiences of mathematics at their school.
- Transition questions – questions that range from the general to the specific, such as: Are there sufficient resources for mathematics education at the school?
- Key questions – questions that specifically contribute to the research questions, for example, what type of support the mathematics students receive from mathematics teachers (school), the community (NGOs or private institutions) and from the education department(s)? Do they consider this support to be useful?
- Ending questions – questions that allow participants to reflect on the entire discussion and then offer their positions or opinions on topics of central importance to the researcher, for example, what type of other support do you think would help improve your performance in Mathematics at this school?

However, the researcher was cautious with the use of closed ended questions, as Krosnick (2009) cautions, since they have the ability to restrict answers and limit expressions and might be more suitable and appropriate for statistical techniques used for analysing quantitative data. The focus group interviews took place in the staffrooms at the respective schools. This

location was chosen because it provided adequate space and allowed for interaction between the participants, who were clearly visible to each other, and an informal environment where the students could openly discuss their experiences. In order to have a successful focus group discussion, the researcher followed the four stages in conducting focus group interviews proposed by the International Training and Education Centre for Health (2008), indicated in Figure 4.1.

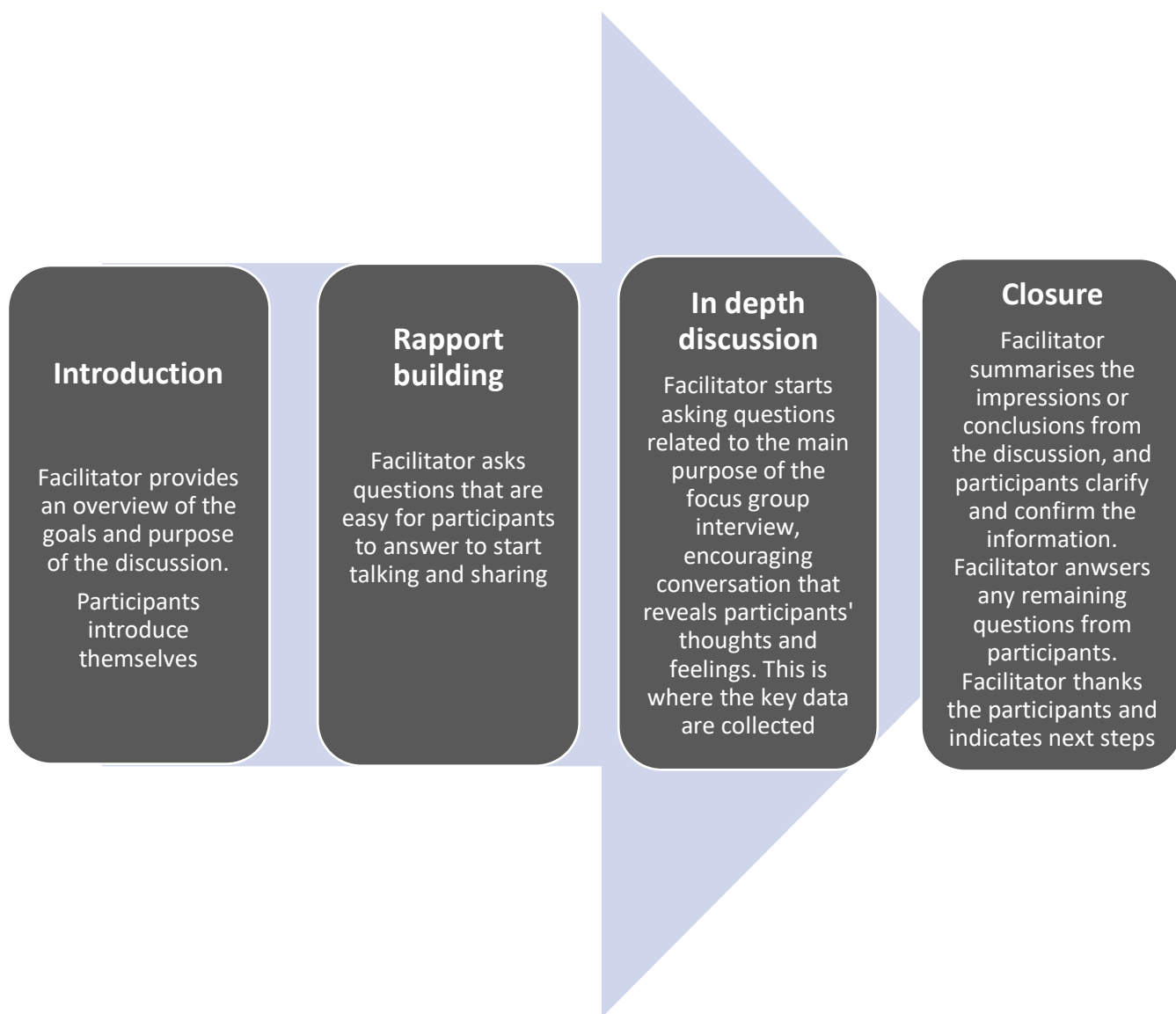


Figure 4.1: Stages in conducting focus group discussions

Source: Adapted from the International Training and Education Centre for Health (2008)

4.6 THE PROCESS OF DATA ANALYSIS FOR THIS STUDY

Bogdan and Biklen (1982: 78) define qualitative data analysis as a process of working with data, organising it, breaking it up into manageable units, synthesising it, searching for patterns, discovering what is important or what is to be learned, and deciding what the researcher will tell others. This data analysis method involves the linking, coding, comparing and the contrasting major categories and themes. When data is collected, it should be analysed concurrently by looking for all possible interpretations. This comprehensiveness involves employing particular coding procedures. Coding consists of naming and categorising data. Babchuk (1997) argues that coding entails assigning meaning to data that are relevant

to the research questions. This suggests that coding by microanalysis, which consists of analysing data word-by-word and coding the meaning found in words or group of words (Strauss & Corbin, 1998: 65-68).

In contrast, analysis of quantitative data focuses more on agreed rules and statistical formulae. It may be said that quantitative data analysis is helpful in evaluation because it provides quantifiable and easy to understand results (The Pell Institute, 2016), and it can be used to generalise concepts more widely and highlight causal relationships (Labaree, 2009).

Three forms of data were analysed in this study: data obtained from the semi-structured interviews and the focus group interviews; data from the survey questionnaire; and documentation and secondary literature on the support policies and programmes of education departments and external providers of support.

4.6.1 Qualitative data analysis

Copies of the audio-recordings gathered from the semi-structured interviews and focus group interviews with mathematics teachers, officials of the Western Cape Education Department and mathematics students were all transcribed before being analysed. All the emerging themes or ideas that belong together were grouped. For instance, data that related to the challenges mathematics students and teachers face from each school were grouped under the heading "*challenges students face*" and "*challenges teachers face*". The ATLAS.ti software was used particularly to analyse interviews, textual sources and other types of qualitative data. The software was used to code, to generate categories and to group raw data from the semi-structured interviews and focus group interviews. Thereafter, the analysed data were compared and contrasted in terms of the different challenges and support opportunities available, accessed and utilised by each school. All themes were compared and contrasted in order to arrive at a holistic view of the situation at each school, regarding mathematics students' and teachers' experience of mathematics education.

4.6.2 Quantitative data analysis

Model fit statistics and item analysis were carried out for each scale using Winsteps. The programme allowed for the person and item total raw scores of the survey administered to 100 mathematics student participants (20 at each of the five schools) to be entered and used, to provide an estimate additive measure. Finally, the output consists of a variety of useful

plots, graphs and tables suitable for import into written reports, of which graphs were used for the purpose of this study.

4.6.3 Document analysis

Official documents on relevant educational policies were obtained from the Western Cape Education Department and the national Department of Basic Education. To facilitate the analysis of the documents the support programmes for mathematics education at the participating schools and the support opportunities by external providers were grouped together according to the various support opportunities that were accessible and utilised by the mathematics students and teachers at the different schools. The analysis of the documents was supplemented by relevant secondary literature on various forms of support for mathematics students and teachers.

4.7 ADDRESSING ETHICAL ISSUES OF THE STUDY

Regardless of the type of research, ethical issues are important in all types of research. According to Sanjar, Bahramnezhad, Fomani, Shoghi and Cheraghi (2014), the relationship and intimacy that is established between the researcher and participants in qualitative studies can raise a range of ethical concerns, such as respect for privacy, the establishment of open and honest interactions, and avoiding misinterpretations. Similarly, in quantitative research, ethical standards are aimed at preventing activities such as fabrication or falsification of data (Gorazd & Aleksander, 2010). Guided by research ethical standards, the researcher would strive to minimise the possibility of intrusion into the autonomy of study participants. In this study, an information sheet was administered to all participants prior to the commencement of the one-on-one interviews, focus group interviews and administering a survey questionnaire (see, Appendix C). The information sheet addressed the following concerns:

- to introduce the researcher to the prospective study participants;
- to inform the participants of the purpose of the intended research;
- to inform the participants of the reasons for their participation;
- to inform the participants about the voluntary nature of their participation;
- to inform the participants of the confidential nature of the research (safe storage of generated data, disclosure of information, the use of pseudonyms); and,

- to inform the participants of the potential risks or harm arising from participation in the research, and recourse to assistance if needed in the event of any harm occurring or concerns arising.

The informed consent documents are usually associated with issues of disclosure, understanding, decision-making capacity, and voluntariness (Cahana & Hurst, 2008). In this study, all participants signed consent forms to affirm their participation in the study (Appendix D). In addition, the researcher obtained a permission letter from the Western Cape Education Department to conduct research activities in identified educational districts and schools (Appendix A). Upon submitting a final proposal to the Faculty Research Ethics Committee at the Cape Peninsula University of Technology, providing full disclosure of the aim, objectives and procedures of the research project and describing the prospective participants for the intended study, an ethical clearance compliance form was issued (Appendix B). The National Health and Medical Research Council (2007) states that when audio- or video-recording an individual or group of research participants, respect for the participants is crucial.

4.8 CONCLUSION

In this chapter the research methodology and the research design of the study were presented and discussed in detailed. The chapter was divided into four main sections: the first part described the philosophical perspectives of the study (Section 4.2); the second part outlined the research methodology and design (Section 4.3); the third part outlined the instrumentation process and related data collection methods (Section 4.4); and the final part described the data analysis as well as explaining the inherent ethical issues of the study (Section 4.3.3).

It has been pointed out that the study is underpinned by the constructivist/interpretivist and positivist paradigms, which both shaped the research design. The explanatory research design selected makes use of the case study strategy. The case study strategy of research, which allows for the use of both qualitative and quantitative data collection methods, was further elaborated upon in terms of the sampling procedure used and ethical considerations. The data collection methods and instruments described include one-on-one interviews, focus group interviews, surveys and document analysis. Here attention was also given to the strengths of using a mixed-methods approach and its applicability for this study, and the applicability of the various data collection instruments to this study. Finally, a description was given of the

analysis of data, with a focus on how the ATLAS.ti computer software was used in the analysis of the qualitative data, the instruments used in the analysis of the quantitative data, document analysis, and a discussion of the trustworthiness of the study by providing a brief outline of the reliability and validity techniques used in the study.

In the next chapter the findings of the analysis of the qualitative and quantitative data and documentary evidence are discussed.

CHAPTER 5

DATA ANALYSIS AND PRESENTATION OF RESULTS

5.1 INTRODUCTION

This chapter is presented in three parts. The first part focuses on the challenges experienced by Grade 12 mathematics students in the teaching and learning of mathematics at the five participating high schools in the Cape Flats, as reported by study participants (Sections 5.2 and 5.3). Both quantitative and qualitative data were analysed and the results are presented in this chapter. The quantitative results were obtained through a survey questionnaire administered to 20 students who were doing mathematics in Grade 12 at each of the five participating high schools.

The results of the qualitative component of the study were obtained from: (1) the focus group interviews conducted with 20 students in Grade 12; (2) semi-structured interviews with two mathematics teachers in each grade level, namely, Grades 8 to 10 and Grades 11 and 12, at each of the participating schools; and, (3) semi-structured interviews conducted with five district curriculum advisors of mathematics each being responsible for each of the five high participating schools. The latter was aimed at determining: (1) the policies crafted to guide the mathematics teaching and learning support services by the Western Cape Education Department (WCED) in schools in their jurisdiction; (2) the key measures of support provided by the WCED to improve students' academic performance in mathematics; and (3) the extent of students' and teachers' utilisation of educational support opportunities in participating schools. Data was also generated from exploration of certain sections of WCED national policies in a form of document analysis, particularly sections of policies reflecting on support for mathematics teaching and learning in schools.

The second part of this chapter focuses on the educational support that the participants had accessed, and were also being utilised at the time of conducting the study, to address the observed challenges (Section 5.4.1). Types of support services mentioned included the support for mathematics teaching and learning provided by the officials (MCAs) of the WCED. The third part of the chapter (Section 5.4.2) focuses on the strengths and limitations of all the mathematics support opportunities mentioned in the second part, and those support opportunities available to the participants.

Bronfenbrenner's ecological systems theory was used as the framework to locate this study within a comprehensive and integrated context (Section 2.3). The qualitative and quantitative data were analysed and the results are discussed at the first three levels of Bronfenbrenner's ecological systems theory, namely the microsystem, mesosystem and exosystem.

The microsystemic level refers to the relationships and interactions people have with those closest to them, in other words those with whom they have direct contact. This could be the parents, siblings and those at the day-care, school or work place. For the purpose of this study, the researcher focused on interactions and relations between the parents and the child (*student*), that is, what challenges the child (*student*) experiences in mathematics with regard to the provision or lack of parental support in mathematics.

From the research conducted in this study, it is evident that the challenges mathematics teachers' face has a direct impact on how mathematics students experience mathematics. In Bronfenbrenner's ecological systems theory, the relationship between the teachers and students is bi-directional, implying that what affects the teachers will affect the students, and vice versa. Therefore, mathematics experiences of teaching cannot be addressed without addressing possible outcomes on student mathematics learning, which leads to the next system within the above-mentioned systems theory, the mesosystem. The mesosystem consists of interactions between the different parts of a person's microsystem. The mesosystem is where a person's individual microsystems do not function independently but are interconnected and assert influence upon one another. The mesosystemic level emphasises the connections between home, neighbourhood, school, and day care. In this study reference is made to the challenges experienced by the mathematics teacher (school) and the mathematics student.

At the exosystemic level, the research focused on the support availed to mathematics students and teachers by the WCED, as expressed by the MCAs, and that of external organisations (private and non-governmental organisations).

5.2 MICROSYSTEM: CHALLENGES FOR MATHEMATICS STUDENTS REGARDING PARENTAL INVOLVEMENT AND SUPPORT

5.2.1 Results from students' questionnaire

The results in this section of the chapter are based on mathematics students' perceptions of the level of parental involvement and support they receive from their parents towards mathematics education issues. Data in this regard were collected using a questionnaire administered to the students (Appendix H). The questionnaire results reflect on students' perceptions of the aspirations their parents have for their children. Figures 5.1 to 5.5 illustrate students' perceptions, expressed as percentages, of the extent to which their parents:

- allow them to choose their own school subjects;
- view obtaining a Bachelor's pass in Grade 12, not necessarily in mathematics, as important in order to obtain access to tertiary education;
- emphasise the importance of taking mathematics as a subject at school;
- discuss career options with their children; and
- emphasise the importance of performing well at school, in general.

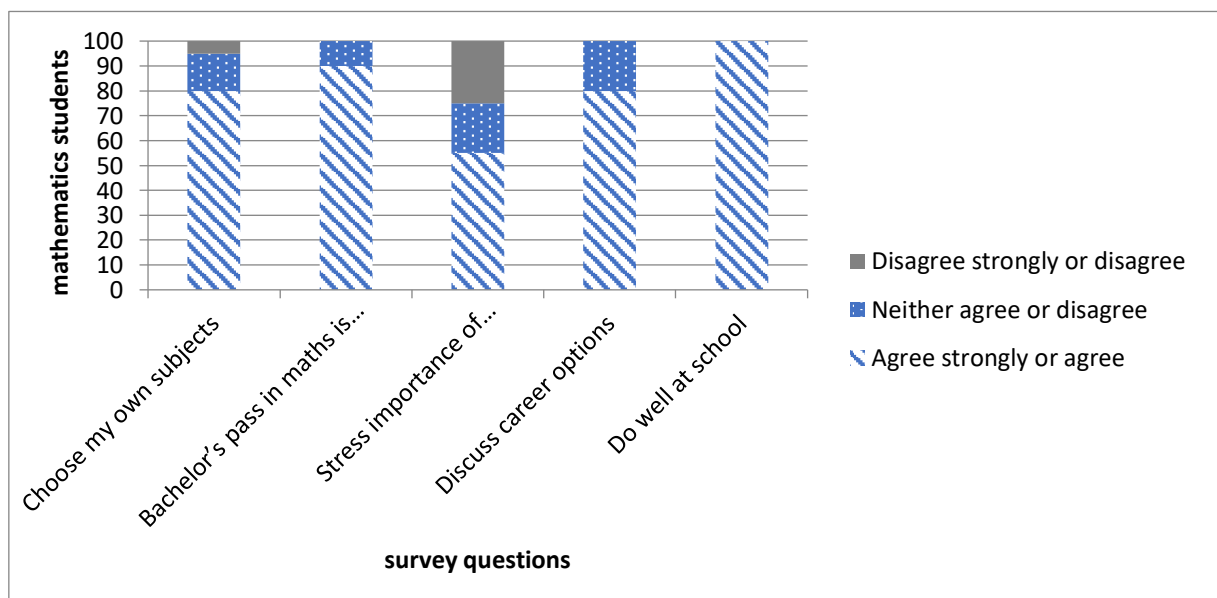


Figure 5.1: Aspirations of parents of Grade 12 mathematics students at school A

Figure 5.1 shows that in terms of parental aspirations, of the 20 students in school A, 16 (80%) stated that their parents allow them to choose their own subjects at school. In this school 18 (90%) students felt that their parents consider the attainment of a Bachelor's pass in mathematics as important in furthering their tertiary education, while 16 (80%) of the

respondents were of the opinion that their parents discuss career options with them. Only 11 (55%) of mathematics students perceived their parents as emphasizing the importance of mathematics as a subject. It seems parents of students in school A want their children do to well at school.

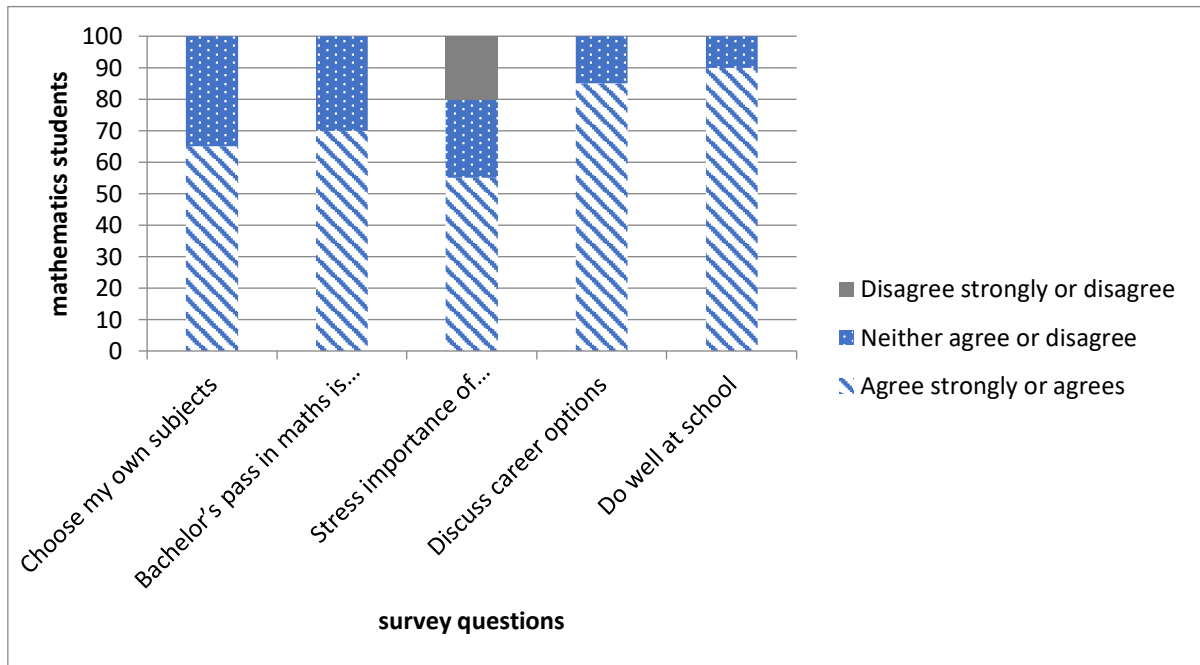


Figure 5.2: Aspirations of parents of Grade 12 mathematics students at school B

In comparison to School A, only 13 (65%) of the 20 respondents at school B specified that their parents allow them to choose their own subjects at school. Of these respondents 14 (70%) expressed the view that their parents felt that a Bachelors pass in mathematics is important. Only 11 (55%) respondents felt that their parents stressed the importance of mathematics in comparison to other subjects, while 17 (85%) of students at this school indicated that their parents discuss career options with them. As perceived by the student participants, 18 (90%) of the parents at school B want their children to do well at school.

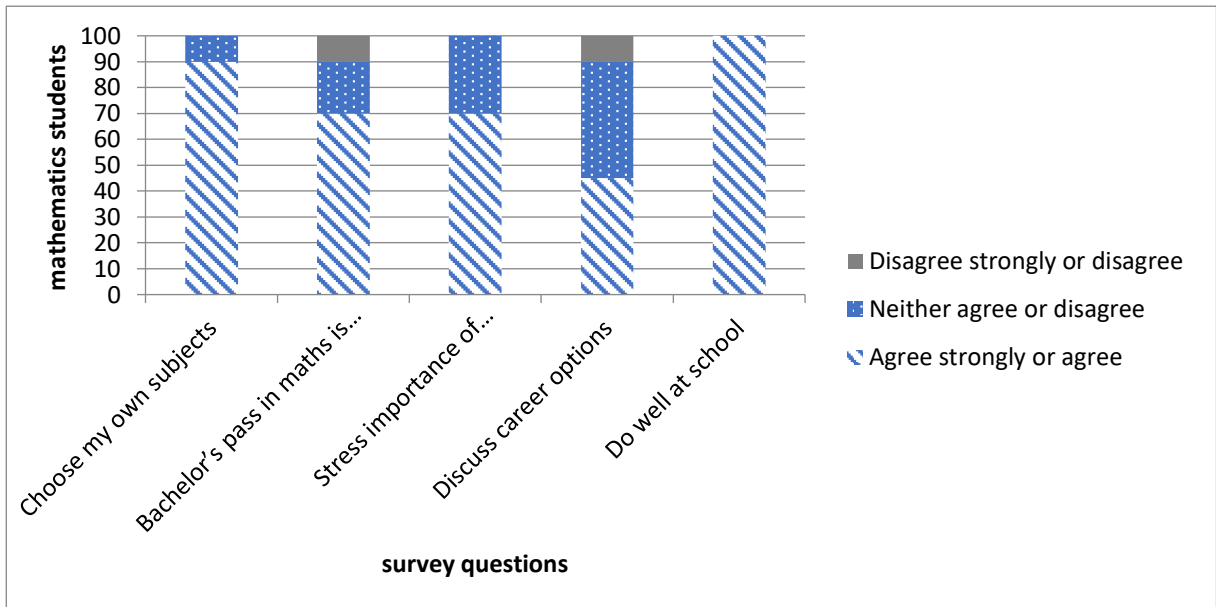


Figure 5.3: Aspirations of parents of Grade 12 mathematics students at school C

In terms of parental aspirations, 18 (90%) of respondents at school C, more than those at both schools A and B, stated that their parents allow them to choose their own subjects. Of these respondents in school C, 14 (70%) felt that their parents considered a Bachelors' pass in mathematics to be important. Unlike the parents of students at schools A and B, 100% (all) of the students at school C responded that their parents regarded mathematics to be a very important subject. However, only 9 (45%) out of the 20 mathematics students stated that their parents discuss career options with them. Similar to school A, student respondents at school C believed that their parents wanted them to do their best at school.

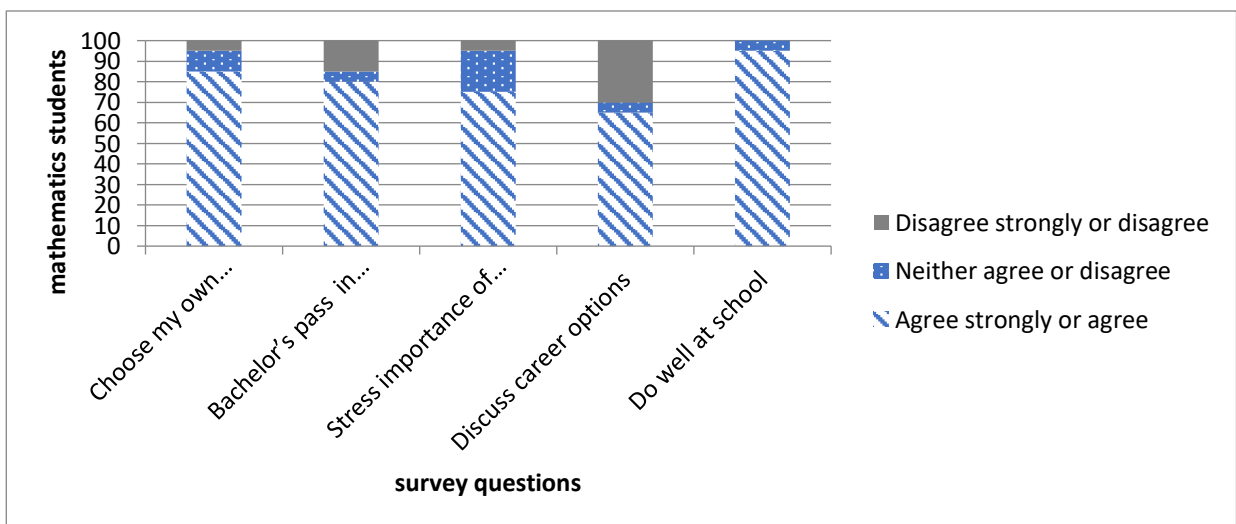


Figure 5.4: Aspirations of parents of Grade 12 mathematics students at school D

As was the case with the student participants at school A, 17 (85%) of students at school D stated that their parents allow them to choose their own subjects. In addition, 16 (80%) indicated that their parents understood the importance of a Bachelors' pass in mathematics. Of these, 17 (85%) students, out of 20, believed that their parents view mathematics as an important subject, while 13 (65%) of the students stated that their parents discuss career options with them. Also, 20 (95%) respondents believed that their parents generally want them to do well at school.

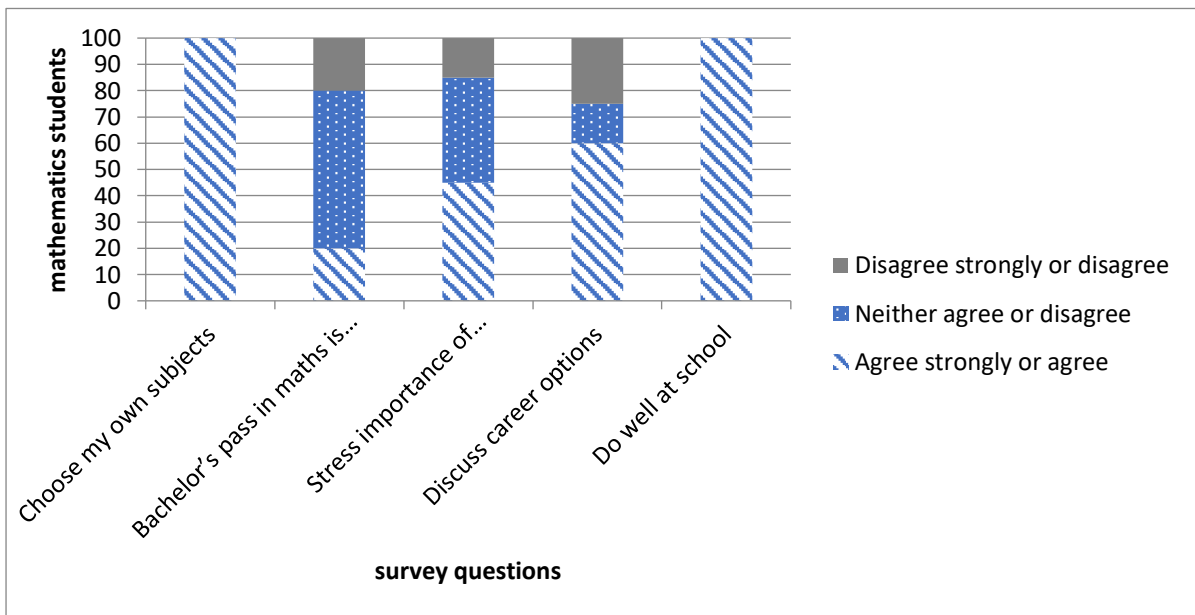


Figure 5.5: Aspirations of parents of Grade 12 mathematics students at school E

All 20 (100%) respondents at school E stated that their parents permit them to choose their own subjects. In contrast, only 4 (20%) of the respondents at school E indicated that their parents believe that a Bachelors' pass is important. School E also ranked the lowest among the five schools, with only 9 (45%) respondents believing that their parents perceive mathematics as an important subject at Grade 12. However, 12 (60%) stated that their parents discuss career options with them. All of the respondents were of the opinion that their parents want them to do well at school, and particularly in mathematics.

Figure 5.6 combines the quantitative results from Figures 5.1 to 5.5 in order to provide an overall understanding of the perceived parental involvement and support received by the mathematics student participants at all of the five schools in this study.

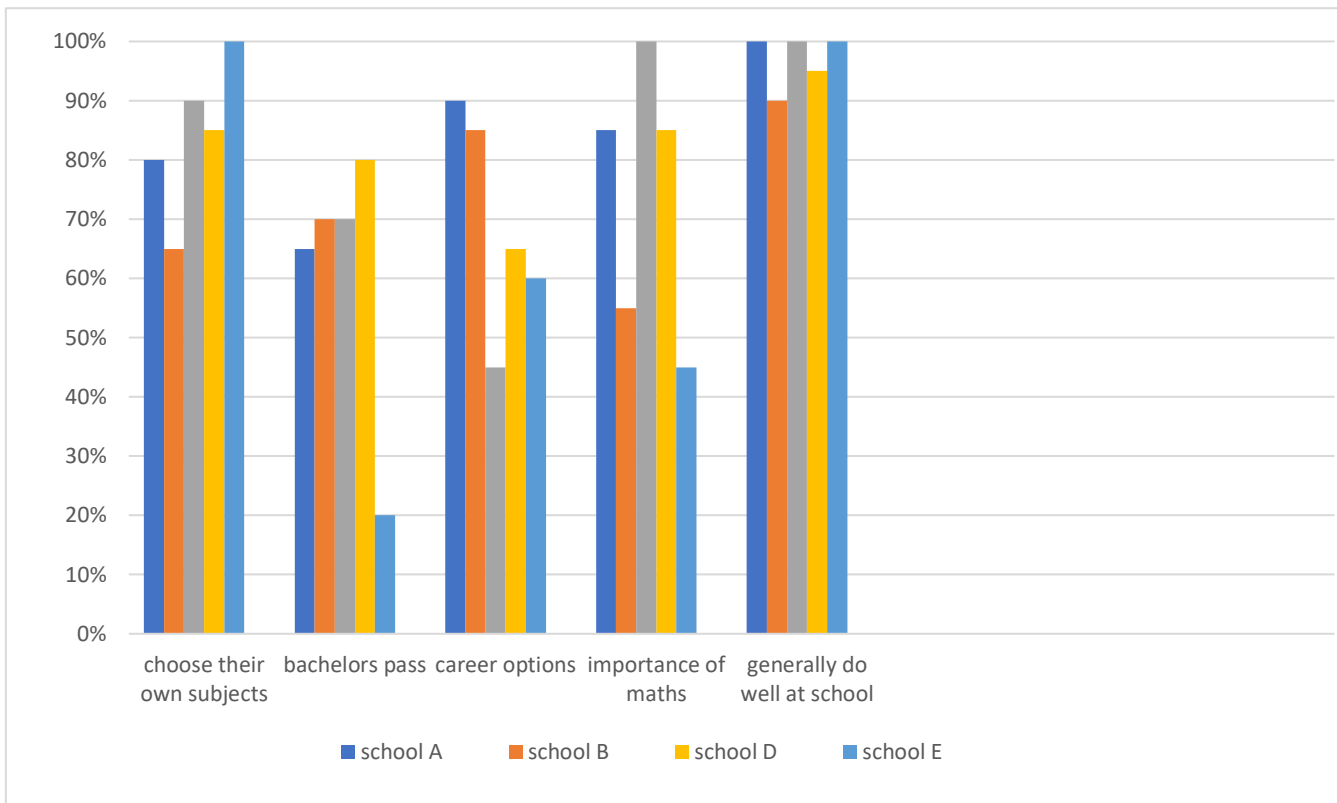


Figure 5.6: Aspirations of parents of Grade 12 mathematics students at schools A to E combined

The overall quantitative results at the microsystem level reveal that most student participants were of the view that parents want their children to do well at school. Parents at four of students in five high schools A, B, C and D have high aspirations for their children in mathematics education. It should be noted from the results that parents of these mathematics students want their children to make independent decisions in terms of their academic future. An average of 80% of the student participants perceived that their parents allow them to choose their own subjects, mathematics being one of them.

These results may suggest that generally parents have confidence in their children's decision-making with regards to their own academic abilities and limitations. These findings are confirmed, particularly in relation to the remaining results. For example, an average of 78% of student participants perceived that their parents consider an overall Bachelor's pass, not particularly in mathematics, to be of importance, with an average of 69% concluding that their parents discuss career options with them. Irrespective of the results in Figure 5.6, an overall 74% of mathematics students perceived that their parents consider mathematics to be very important in their schooling. However, from the students' responses it was not clear whether

the parents understood the importance of mathematics as a subject in terms of prospective tertiary education and future career choices.

Although all the mathematics student participants at school E indicated that their parents allow them to choose their own subjects, the results pointed to a probable lack of interest in mathematics, and possibly schooling in general. Consequently, a meagre 20% of the mathematics student participants perceived that their parents consider passing with a bachelor's pass to be important. Less than a half, that is 45%, of student participants stated that their parents consider mathematics to be a valued subject, and a surprising 60% of students mentioned that their parents discuss career options with them. Although not determined in the results, a possible explanation of the latter point to the parents' general anticipation of their children reaching the end of their schooling.

5.2.2 Results from qualitative data

Part of the focus group interviews conducted with the Grade 12 mathematics students at the microsystemic level was aimed at addressing issues relating to the type of involvement and support the students receive from their parents. The quantitative results reported in Section 5.2.1 serve as a reflection from these discussions.

At all five schools, much of the discussions regarding the type of involvement and support students received from their parents were done with reference to additional mathematics tuition. The apparent reason for this was that several of the student participants mentioned that their parents did not have the educational means of helping them with mathematics at home. The participants indicated that many of their parents have not completed their schooling or left school at a low grade. Other students mentioned that their parents' understanding of mathematics is different from what they are doing in class, and they are therefore not in a position to assist.

Results from the focus group interviews show that participants from schools D and E pointed out that their parents do not have the financial capacity to pay for extra mathematics tuition, which they viewed as a challenge. They added that this results in their inability to complete and cover all the topics in the mathematics curriculum. Only 10 participants from schools A, B and C, out of the 100 mathematics student participants at the five schools, receive parental support in the form of payment for private tuition. The 10 participants mentioned that the

additional mathematics tuition that they were receiving was from institutions such as Shawco and Study Buddies.

According to the Centre for Development and Enterprise (CDE) (2013), the costs of extra mathematics tuition appear to be uniform across the country. Individual lessons range from R150 to R200 per hour, with extremes being R120 and R300. Small groups of two students pay from R100 to R200 per hour each, and the charge for groups of three to five ranges from between R80 and R150 per hour (CDE, 2013). The franchised companies charge between R400 and R800 per month, depending on the number of hours per week. These fee rates for additional mathematics tutoring provide the reader with a distinct picture of possible implications and limitations it has on the mathematics student participants in this study stemming from an under-privileged socio-economic background.

5.3 MESOSYSTEM: CHALLENGES MATHEMATICS STUDENTS AND TEACHERS FACE

5.3.1 Mathematics curriculum

Both the mathematics teachers and student participants mentioned issues of concern related to the mathematics curriculum. The Grade 12 mathematics students who participated in the focus group interviews at schools A, B, C, D and E presented a range of challenges that they perceived as impacting on how they experienced mathematics learning at their respective schools. Teachers and student participants from five schools A, B and D presented various technical and practical aspects of the mathematics curriculum, the Curriculum and Assessment Policy Statement (CAPS), as being a challenge to the mathematics students. Teachers and student participants indicated that they were not able to cope with the amount of work and that this, according to them, remained the biggest challenge in the teaching and learning of mathematics in participating schools. One mathematics student highlighted the amount of work required in the CAPS curriculum as an impediment in the completion of the syllabus. She stated:

CAPS has made it really difficult for us to understand mathematics, as we now have more work and feel very overwhelmed to cover so much work in mathematics in such a short time. We rush to work through the curriculum. It can get overwhelming at times.

Other mathematics students conferred with the above findings:

We have to stay after school to complete the syllabus. Even then we have to work at a fast pace through the syllabus, as the school is locked at four o'clock, meaning that we then have to leave the premises. This does not give us a lot of time to cover important mathematics content.

We noticed that the mathematics teachers neglect to cover some topics, and this is a big problem for us in Grade 12 as we are not sure if the topics we did not do come in the exams.

Similarly, numerous teacher participants pointed explicitly to the complex structure of the mathematics syllabus, which, according to them, makes it difficult to interpret and implement, as one teacher elaborated:

The syllabus is too compacted. It has made mathematics very difficult to teach as it involves limited time to work through the syllabus. We have short periods so we have to rush through the syllabus. The syllabus expects students to know more than what they should. We often have to ask mathematics students to stay behind after school to complete parts of the mathematics syllabus that was not completed in that specific day or week.

This is in agreement with a study conducted by Olivier (2013) to determine teachers' perspective on various aspects of the implementation of the CAPS curriculum in the school classroom. Olivier's 2013 study revealed that approximately 50% (half) of respondents indicated that they were not able to complete the curriculum in time. One of the teacher participants indicated that mathematics students at their school were producing below average results and ascribed it to areas of the mathematics CAPS curriculum being too abstract:

In the CAPS Curriculum, geometry and trigonometry is now more abstract. This is not only a challenge for mathematics teachers teaching the subject, but it is also a challenge to the mathematics Grade 12 students that are not on a Grade 12 level of understanding, especially in those areas in mathematics.

Olivier (2013) further revealed that "more than 90% of the respondents have reported that they have spent a considerable amount of time in the classroom to re- teach/revise content

from previous years to assist students”. This corroborates the response by one of the mathematics student participants at one of the four schools:

We do not have enough time to work through the syllabus (CAPS). Our mathematics teacher has also mentioned this to us. We have too much work. Sometimes we move on to another topic without clearly understanding the previous topics covered.

A significant 45% of FET mathematics teachers representing schools from eight education districts in the Eastern Cape province of South Africa concluded that students do not cope academically with the CAPS mathematics curriculum. A stark similarity established at three of the five schools is the complex structure of the mathematics curriculum (Olivier, 2013).

In response to the findings presented in preceding sections, the Department of Basic Education (DBE) (2013) specifies that the mathematics CAPS curriculum, unlike the previous National Statement Curriculum (NCS), provides a clearer and more succinct statement of what needs to be learnt, and is perceived to be more content driven. Furthermore, the mathematics CAPS policy confirms that a total of 4.5 hours per week is allocated to mathematics teaching and learning.

Figure 5.7 compares the overall weighting of topics to the percentage of the total time allocated to that topic in CAPS. Noticeably, Euclidean geometry has been allocated only 12.5% classtime in comparison to its 16% weighing in terms of marks (DBE, 2015).

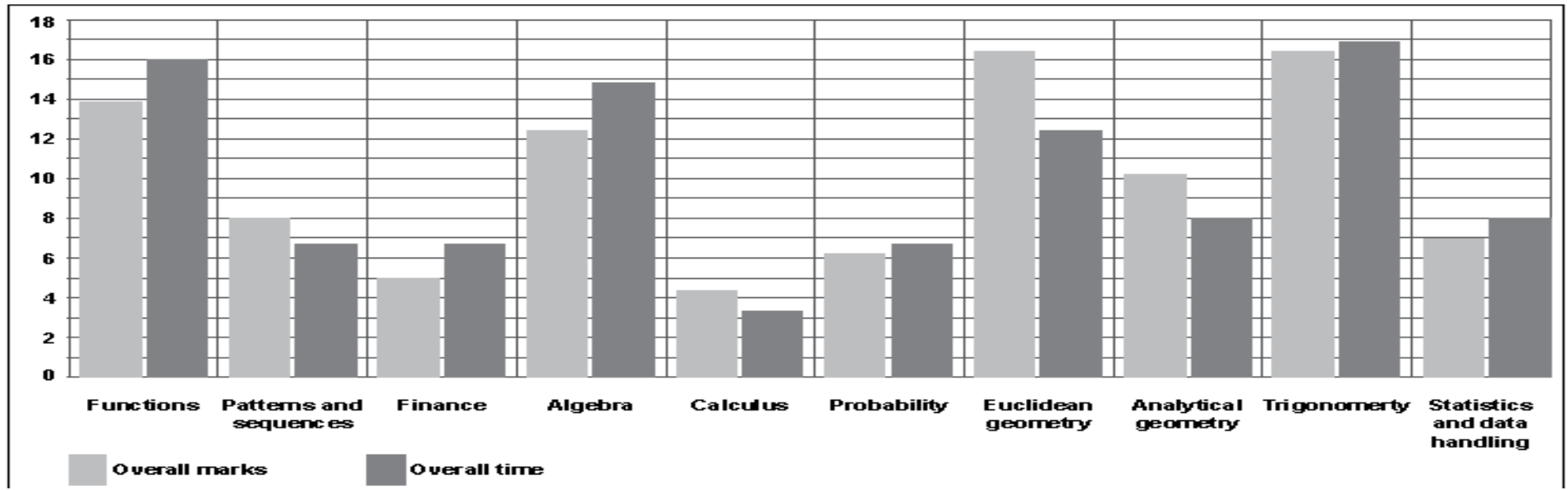


Figure 5.7: Weighting overall percentage of marks and time for each topic in CAPS (DBE, 2015)

Although the specification of content, pace, sequencing and assessment in CAPS has been generally welcomed by teachers, they would prefer it to be less prescriptive with reference to time frames. The pace of the curricula of most subjects is too fast. Educators rush through the syllabus to complete the content, and in doing so, do not spend much needed time with slower students. While some educators are more innovative and would prefer to use CAPS as a guideline and adapt it to suit their students, others felt they needed clear guidelines and structure (Moodley, 2013).

Participants in Moodley's (2013) study elaborated on the general effect curriculum changes have on teachers and students. Teachers, as drivers of change, deserve respect and careful consideration particularly since curriculum change is accompanied by unrealistic demands, and lack of time and resources, amongst other demands, in an effort to understand the required changes (Priestley & Sime, 2005). One of the participants in this study put it as follows:

We had three systems (curriculum) changes in a very short period of time. Our teachers have difficulty keeping up with these changes, and this is especially the case for mathematics. We now have limited time. Working through the curriculum is one of our biggest challenges.

5.3.2 Educational resources in participating schools

A general consensus among all students and teacher participants at all five schools is that their schools have severe shortage of mathematical resources such as new mathematics textbooks, computers, projectors and technological resources, specifically interactive computer programmes, which they consider to be fundamental in 'updating mathematics teachers' teaching methods. Furthermore, the participants revealed that the schools have not been specifically provided with technological resources, and this is a discouraging factor relating to how students understand and interpret mathematical solutions.

Besides the importance of having the necessary educational resources to enhance the teaching and learning of mathematics, it is similarly crucial for mathematics teachers to be confident in the selection of and purpose behind the use of a particular resource, and how it will not only aid but also support the mathematics lesson. Spaul (2013) and Van der Berg (2008) emphasise that whether related to the socio-economic background of the schools or the inability to meet the needs of the mathematics students, higher levels of resources are linked to better educational outcomes. This is confirmed by economists, revealing that the socio-economic status of a school has significant impact on students' performance (Visser, 2015).

With that in mind, it is important to note that the mathematics teachers and students at four of the five schools, schools A, B, C and D and schools A, B, C and E, respectively, disclosed that the lack of mathematical resources has remained a challenge at the schools for many years and has a direct impact not only on their teaching practices but also largely on the

understanding and performance of students in mathematics. According to some of the student participants at school A, mathematical resources enhance their understanding of mathematics, especially of difficult concepts. For example, these student participants mentioned that, in the section on Euclidean geometry in the mathematics text book, reference is made to using a mathematical set.

However, when the mathematics teachers explain geometry on the board, they themselves do not have the necessary resources for demonstration and explanation purposes, thus making it difficult to understand certain concepts. Another example, according to the teacher participants, is the use of scientific calculators, particularly in algebra and trigonometry. Students are not able to solve certain problems in mathematics without the use of a scientific calculator. According to the teacher participants, mathematics students are requested to acquire a scientific calculator as early as Grade 8. However, it seems that half of the mathematics students in this study do not possess this invaluable resource. The Western Cape Education Department apparently does not provide such resources to students, and students therefore have to obtain these themselves.

Some mathematics teacher participants went as far as to imply that the students (parents) are able to afford expensive mobile phones but are not able or willing to buy these compulsory mathematical sets and scientific calculators. Although not mentioned, it can be deduced from the student participants' responses that a possibility exists that parents and/or the students do not consider the acquisition of such resources as valuable in the learning of mathematics or they feel that it is the Western Cape Education Department's responsibility to provide them with these resources, therefore shifting responsibility and accountability.

5.3.2.1 Textbooks

At least four of the five schools' participants (students and teachers) from schools A, B, C and E, agreed that they consider the lack of mathematics textbooks to be one of the major challenges in their experiences of mathematics education at their schools. The mathematics teacher participants indicated that, although policy states that all students should have textbooks, this is simply not the case in practice. The teacher participants revealed that order forms for mathematics textbooks are completed a year prior to the academic year of the enrolled grades and submitted to those responsible. However, according to some of the teacher participants, no specific reason is provided for the justification of these waiting

periods. The teacher participants made it clear that they are not aware who is accountable and responsible for the delivery of these textbooks, and upon questioning about this matter, it often turns out to be a situation of 'shifting the blame', thus pointing to the poor management skills of those responsible within the Western Cape Education Department for these tasks. In addition to this, there also exists a possibility of no clear specification of job responsibility.

At four of the five schools (A, B, C and E), the student participants indicated that they lack new and updated mathematics textbooks. This, they explained, makes them feel insecure about the topics and content in mathematics. A participant at one of the schools expressed her views as follows:

Because of the lack of mathematics textbooks at the school, we are worried if the mathematics teacher is covering all the topics in mathematics that we are supposed to do to prepare us for the exams. All of us in the mathematics class have not had a mathematics textbook since the beginning of the year. We work through old mathematics textbooks.

Another student pointed to the mathematics teachers substituting the shortages of mathematics textbooks by using alternatives as follows:

Our mathematics teacher gives us copies of mathematics content from her own textbooks she sourced.

Learning theorists have suggested that students' mathematics concepts evolve through direct interaction with the environment, and materials (resources) provide a vehicle through which this can happen (Abaya, 2017). Mathematics textbooks alone cannot provide for these experiences. Likewise, Lesh (1979) and Piaget (1968) emphasise the value of concrete experiences in mathematical problem solving. In the broadest sense, it may be said that mathematical resources, including mathematics textbooks, provide a tool for concrete experiences in mathematics teaching and learning, and can be considered invaluable. Valverde, Bianchi, Wolfe, Schmidt & Houang, (2002) believe that the structure of mathematics textbooks is likely to have an impact on actual classroom instruction. The pedagogical model only becomes effective when the textbook is actually used. Students incorporate their mathematics textbook as an instrument into four activities: solving tasks and problems,

consolidation, acquiring mathematical knowledge, and activities associated with interest in mathematics (Moloi & Strauss, 2005).

Moloi and Strauss (2005) state that textbooks should, as accurately as possible, communicate the ideals of the curriculum and purvey images of what society expects from those who go through the schooling system. The mathematics textbook was, and still is, considered to be one of the most important tools in this context. According to Howson (1995), new technologies have not affected its outstanding role: “despite the obvious powers of the new technology it must be accepted that its role in the vast majority of the world’s classrooms pales into insignificance when compared with that of textbooks and other written materials” (p. 21).

Supplementary to the above situation with mathematics textbooks, student participants also pointed to having ‘outdated’ textbooks. This appeared to be a challenging factor at all of the five schools. According to the student participants, the mathematics textbooks that they possess are not beneficial, as the content in these textbooks does not coincide with the mathematics topics discussed in the classroom, and this makes them feel rather insecure whether all the necessary topics are covered, specifically for exam purposes. Some students voiced their concerns as follows:

*We have mathematics textbooks, but we are not able to use them as they are outdated.
The mathematics content we cover in class does not appear in the textbooks.*

Another participant elaborated:

The questions we get in the mathematics exams are not dealt with in the mathematics class. Also, we have no other resources besides the mathematics textbooks that we cannot really use, as the mathematics work the teacher does in the class appears to be different from that in the mathematics textbooks.

Johansson (2003) focuses on such deficiencies of some mathematics textbooks and its effects on the teaching and learning of mathematics. Many textbooks do not contain much content that is new to students. The lack of attention to new material and heavy emphasis on review in many textbooks are of concern, particularly at the elementary and middle-school levels.

De Corte (2000) examined several textbook series and found that fewer than 50% of the pages in textbooks for Grades 2 through 8 contained any material new to students. Textbooks that

devote much attention to review and that address little new content each year should be avoided, or their use should be heavily supplemented in appropriate ways. Teachers should use textbooks as just one instructional tool among many, rather than feel duty-bound to go through the textbook on a one-section-per-day basis.

As a way of alleviating the situation, some of the student participants stated that the mathematics teachers are provided with an updated copy of the mathematics textbooks and often make copies of the work that is to be done on a daily basis. Furthermore, they indicated that the mathematics teachers provide them with several other worksheets from various mathematics textbooks. This method of intervention alleviates some of the challenges they perceive from not having new, updated mathematics textbooks. These responses suggest that, irrespective of the mathematics textbook challenges, some of the mathematics teacher participants at the five high schools make a concerted effort to remedy the situation.

5.3.2.2 Digital and electronic resources

Clark-Wilson, Oldknow, & Sutherland (2011) agrees that in terms of digital resources, it seems that 'the use of technology within mathematics is underused and, where it is used, its potential is generally underexploited'. These findings correlate with the teacher participants' perspectives and responses to the resource situation at four of the five schools (A, B, C and E) as elaborated:

Having a lack of resources for mathematics is a major problem, especially technological resources. Although we have a lot of computers at the school, none of them are in working condition. We have no internet so we are not even in a position to download mathematics programmes for the mathematics students. We still use the traditional methods of teaching and that is the white board. And even that is a problem as we have limited space for writing on the board, especially if you have many different mathematics classes. So, we rather make copies of mathematics worksheets and hand it to the students.

A student participant at the same school confirmed this:

Our mathematics teacher only provides us with photocopied worksheets. We do not much make use of technology in the mathematics class. There are no computers,

laptops . . . It feels almost like we are regressing when it comes to using technology. The only resources we can use are calculators.

Dick and Hollebrands (2011) state that in a balanced mathematics programme, the strategic use of technology strengthens mathematics teaching and learning and has an impact on how mathematics is taught, and what aspects of mathematics are taught (National Council of Teachers of Mathematics, 2000).

Similarly, there is also a situation of having mathematical resources that are not in working condition, and this has negative implications for the learning of mathematics as mentioned by student participants at one (A) of the five schools:

We have projectors at the school, but the mathematics class projector has never really been working. When we go to other subject classes, we see how useful it is. Also, we don't have any internet. We have computers though, but it is the really old ones with the small screens. And most of them are not working either.

All participants (teachers and students) at the five high schools mentioned that the lack of internet connectivity and Information Technology (IT) support remains one of the greatest challenges in terms of technological resources. Not having technological resources is one aspect. For the limited available resources that the schools do have, there exists a serious lack of IT support as far as the management (*in relation to accountability factors*) and maintenance of the schools' computer laboratories are concerned. According to the participants, in practical terms this means that the software installed becomes non-functional and serves no real purpose.

In addition to the above, the participants at all of the five high schools highlighted the lack of use of technology in the classroom, including the prohibition of the use of computer or mobile applications. The participants indicated that they were not allowed to use their mobile phones to do research, or to use a search engine such as Google. Thus, they were also barred from using what they consider to be useful mathematics applications on their personal devices. This can be viewed as a major disadvantage, considering that four out of five, or 81%, of secondary school students in South Africa own or have access to a mobile phone, and about 31% have their own social network page (Mascheroni & Ólafsson, 2014). Whereas only 10% of South

African schools have access to one or more computers (Mdlongwa, 2012), only 3.95% of South African households owns a computer (Arthur, 2012).

Other debilitating factors having an impact on resource utilisation at the schools, according to some student participants, is the lack of teacher knowledge and understanding of the utilisation and operation of certain resources. The student participants made specific reference to projectors that teachers are unable to operate. By way of explanation, the participants discussed concerns specifically related to mathematics teachers not receiving the required training to operate and utilise such equipment. This is reflected in the following response:

Some teachers find technology intimidating, especially the older teachers. They do not really make an effort to learn how to use the projectors. So, they stick to the black board and chalk method. This is not necessarily a good thing for the mathematics students.

The teacher participants at the same schools did not mention the above factors as being a concern in the utilisation of resources. The validity of the student participants' responses with regard to the teachers' lack of knowledge and understanding of the utilisation and operation of certain resources could not be verified.

Nelson, Christopher and Mims (2009), and Pierce and Stacey (2010) emphasise the importance of programmes in teacher education and professional development that allow for continuously updating practitioners' knowledge of technology and its application to support learning. The authors stress that this initiative with practitioners should include the development of mathematics lessons that take advantage of technology-rich environments and the integration of digital tools in daily instruction, instilling an appreciation for the power of technology and its potential impact on students' understanding and use of mathematics. According to the National Council of Teachers of Mathematics (2011), in an ideal situation, all schools and mathematics programmes would provide students and teachers with access to instructional technology — including classroom hardware, handheld and lab-based devices with mathematical software and applications, and Web-based resources — together with adequate training to ensure its effective use.

5.3.2.3 Human resources

Teacher participants at two of the five schools (A and D) revealed that they experience a shortage of human resources, such as qualified mathematics teachers. One participant went as far as saying that the Department of Basic Education is hesitant to employ foreigners in available positions for mathematics teachers at the school. The participant stated the following:

The Department claims that it cannot employ foreign teachers in permanent positions because they do not have permanent residency. This is a particular limitation because the foreign mathematics teachers are often highly qualified and suitable for permanent positions.

The shortage of human resources in the form of qualified and experienced mathematics teachers was confirmed by the presence of a foreign, recently qualified mathematics teacher at school A. The Department of Basic Education (DBE, 2011) and the Department of Higher Education and Training (DHET, 2011) agree that there is both an absolute shortage of teachers and a relative shortage of qualified teachers competent enough to teach specific subjects (including mathematics). This situation presents an additional challenge in that teachers have to teach mathematics in overcrowded classrooms. An implication of the above, according to student participants at one of the five schools (D), is that teachers are not able to provide individual attention and assistance to low performing mathematics students.

5.3.2.4 Societal factors impacting on resources

Other incapacitating factors contributing to the lack of resources at one of the four schools (C) pointed to the culture of violence and gangsterism that arises from the social conditions in the area where the schools are located. Some of the teacher participants mentioned that the students have the tendency to vandalise and destroy the resources given to the school, including mathematical resources. This is evident in the following statement:

The mathematics textbooks are however in a bad condition, as the students vandalise them. Students vandalise the little resources given to them. We also have security issues. Students steal the resources; that is why everything has to be locked up in the principal's office.

One of the student participants at the same school had the following to say:

There is a big problem of stealing at our school; so, we have to carry all our resources that we bring to school, our phones (to calculate) and other resources on ourselves the entire day. They also break in to our schools and steal our computers . . .

5.3.2.5 Concluding remarks

According to the teacher participants at school E, the school did not experience a shortage of resources, whereas the student participants at the same school disagreed. Similarly, the student participants at school D declared that they did not lack any resources; however, the teacher participants at the same school did not share this view. It could not be determined what the true situation was at the two schools with regard to resources. What was evident is that the student and teacher participants at these two schools had differing perspective and views on what constitutes a problem or a challenge in terms of resources.

Teacher participants at school E however had the following to say regarding how they experience the challenges of a lack of resources:

We buy our own resources as there is no budget for resources. For example, we download our own mathematics programmes from the internet. This often costs us a lot of money. We do, however, have a few projectors and visual information in the form of posters in our classrooms that we received from the Education Department.

The teacher participants concluded that the WCED and the DHET ultimately remain accountable for the dire situation of not allocating sufficient resources to their schools.

The need for mathematical resources appeared not to be an issue at school E, with the teacher participants indicating that they have sufficient resources such as projectors, mathematics computer programmes, geometry sets for students and white boards. They do, however, acknowledge that they have a shortage of mathematics textbooks, but provide an unassuming explanation as to why this is not detrimental to the teaching of mathematics at the school, as verified by one of the participants:

We have some mathematics textbooks however, not for every single student. We do not really use the mathematics textbooks as we find that the information in the books does not correlate with the syllabus. Also, the books are so damaged that the mathematics students cannot really use them. Some pages are missing, there is no

cover...In most of the instances the students damage the textbooks themselves. That tells you that they have a lack of respect for the subject.

The participants at school E concluded that, unlike other schools in the area, the school principal has involved various stakeholders to donate and supply the school with various resources. Meador (2017) confers that the role of the school principal in having a good standing in community relations is critical as the school can only benefit from this type of support in the form of donations and those providing services and their personal time.

According to teacher and student participants at all of the five schools, it can be concluded that the deficiency of mathematics textbooks and resources, especially that of a technological nature, not only has a negative impact on students' mathematics performance in general, but also limits the implementation of various instructional practices and teaching methods in the mathematics classroom.

5.3.3 Teaching methods

Mathematics teachers' practices have a notable impact on the learning and teaching of mathematics in any given situation. Mathematics has the ability to use teaching practices that can develop mathematical thinking practices and mathematical proficiency among students. Boaler (2002) emphasises that the teaching practices that teachers employ in their teaching, for example asking challenging questions, can become practices that students use in their learning. As teachers and students work together in a community of practice, mediating knowledge with and for each other, students can internalise the teachers' practices to build their own mathematical practices and reasoning. The lack of such teacher practices appears to be paramount in explaining how the student participants at school B perceive and experience mathematics education at the school, as voiced by one student participant:

What is confusing to us is that different mathematics teachers use different teaching methods. It is almost as if they do not know the mathematics content themselves. They do not know how to explain the work to us. What makes this problem even worse is that we had several different mathematics teachers in one year.

Moore (2012) recommends that mathematics teachers use common strategies in teaching mathematics, including direct instruction, cooperative learning and problem-based instruction.

Moreover, the constant rotation of teachers to teach different subjects, and particularly the employment of new mathematics teachers on an irregular basis, were considered by the teacher participants at two schools (B and C) to be problematic for mathematics students in all grades. The reason behind this statement, according to some of the participants at school B, is that mathematics teachers use different teaching methods, thus creating confusion amongst mathematics students, possibly due to different training and qualifications or the lack thereof. This has an impact on students' understanding and interpretation of the mathematics content imparted to them, as voiced by a teacher participant at school B:

We would really like to see one teacher teaching mathematics to at least one class from the Grade 8 level to the Grade 12 level. The reason being that different teachers have different teaching methods and this can be confusing for the mathematics student. If this were to be the case, the mathematics teacher for a particular group would be able to remedy mathematics problems through early identification.

The above participant at school B suggested that if one mathematics teacher was allocated to one mathematics group from Grade 8 to Grade 12, they would be able to know what content in mathematics needs to be covered at the next level and could allow for a positive attitude towards the understanding of the subject content.

Student participants at school C were of the same opinion as the participants at school B with regard to mathematics teachers' instructional practices, as put by a participant:

My mathematics teacher does not know how to teach mathematics. She only writes notes on the board and refers to examples in the mathematics textbooks. We noticed that she neglects to cover some topics, and this is a big problem for us in Grade 12 as we are not sure if the topics we did not do come in the exams.

However, teacher participants at school B maintained that mathematics teachers at the school do not possess the necessary confidence in teaching mathematics, which they presume, has its roots in a lack of available continuous professional and subject development programmes for mathematics teachers. This is particularly the case for the 'older' mathematics teachers at the school, as indicated by this statement:

We (mathematics teachers) really do have major challenges in finding effective methods to teach mathematics as some mathematics students appear to have no

interest in learning mathematics. Most of the mathematics students in my class refuse to complete their daily mathematics activities, we contemplate could be due to a lack of understanding.

It should be noted that the teacher participants at school C had no particular viewpoint with regards to the above-mentioned challenges in their mathematics teaching methods. Teacher participants at schools A, D and E expressed no apprehension regarding challenges around mathematics teaching methods.

5.3.4 Mathematics support opportunities

The student participants at all of the five schools (A, B, C, D and E) emphasised the lack of mathematics support opportunities available at their schools, and remarked that this dilemma undoubtedly has a considerable effect on their mathematics performance. MacGillivray (2009) agrees, describing the use of mathematics tutoring support programmes to be a useful strategy to improve the performance of mathematics students. More importantly, all of the student participants at the five high schools were candid about the challenges they encounter at their schools and were in a strong agreement that their school does not offer any support for students that are struggling in mathematics at the FET level.

According to some student participants at school A, the mathematics support that are offered are not very convenient, as most of the students do not have the means to attend these programmes. It was put as follows by one of the participants at school A:

There is no mathematics support programmes at our school. My mathematics teacher informed us about an after-school online mathematics support programmes at a school not far from here. However, only the mathematics students that stay in this area are able to attend this programmes. The rest of us are waiting on our transport. So we miss out on such an opportunity. Some of our parents cannot afford extra mathematics tuition, so some of us have to struggle on our own.

Similar to school A, the participants at school B made it clear that students are not receiving any information on the availability of mathematics support programmes from the school and the Education Department(s). One participant at school B went as far as to utter the following words to express the Grade 12 mathematics students' frustration:

I want to write a letter to the Education Department to ask them why our mathematics teachers are not aware of any mathematics support programmes for us that can be presented or offered at our school. It is indicated in the code of conduct in the school policy that we are supposed to be informed of mathematics support opportunities available for mathematics students. This is a big challenge for us doing mathematics in Grade 12. We receive no support in mathematics at our school; nothing at all.

A similar picture emerged from the participants at schools C and D. The students had strong views and concerns surrounding the deficiency of mathematics support opportunities at public schools in general, and had no hesitation sharing their views, as in the case of one participant at school D:

Our country wants us to succeed in maths so that we can have more opportunities to improve the employment rate in our country for skilled people in fields of technology, business and medicine. The problem is: the government is not willing to invest money into maths support programmes for students like us whose parents cannot afford private tuition or private schools.

Unlike participants at school D, some of the participants at school E held the school principal responsible for this problematic situation. The participants expressed a very negative view about the lack of communication from the principal regarding available mathematics support programmes :

The principal does not tell us or the mathematics teachers about mathematics support opportunities. We have to find out about it from students from other high schools in the area, such as the mathematics support opportunities/tutoring offered by SHAWCO and UCT. They probably think it will not be helpful to us.

No teacher participant at any of the five schools particularly viewed the lack of mathematics support opportunities as a key problem. The findings suggest that the teachers at the schools are aware of mathematics support opportunities available to students, and that other schools (in the immediate vicinity of their own schools) offer after-school mathematics support to students in need. One possible explanation for the above responses from mathematics teacher participants could be perceived work overload, to the point that any after-hours attendance of non-compulsory in-service training, mathematics support programmes,

workshops or seminars are deemed superfluous. Another possible explanation could be a lack of commitment to the challenges at hand.

The importance of small group tutorials for mathematical support could not be more stressed in terms of increasing and improving mathematical performance. Moreover, it can be considered an effective method in enhancing student mathematics confidence and ultimately employability, especially to those students who needs it (MacGillivray, 2007; Van Veggel & Amory, 2014).

5.3.5 Primary school preparation for high school mathematics

The acquisition of numeracy skills in the foundation phase is viewed as fundamental to successful learning in later phases, especially in mathematics at Grade 12 level (Machaba, 2013). Student participants at four of the five schools (A, B, D and E) expressed no concerns regarding their mathematical knowledge and skills when they started with high school mathematics. However, the mathematics teacher participants held a different view. Teacher participants at school A described the challenges they experience with bridging the gap between primary school and high school mathematics. They indicated that students in the beginning of the year in Grade 8 do not possess the necessary knowledge and skills to cope with mathematics at a high school level. This means that mathematics teachers have the additional task of re-teaching certain mathematical knowledge and skills essential for understanding mathematics at the high school level. The latter implies that students did not obtain the basic mathematical skills at the primary school level, with many students lacking the requisite foundational understanding in mathematics.

Identical with the responses of participants from school A, teacher participants at school B illustrated an image of students failing to meet the basic requirements in mathematics when they reach high school (Grade 8). The implications of this are that it creates a backlog of knowledge which deteriorates the situation, particularly for these students at the FET level (Grade 10 to 12), as explained by one of the participants:

Mathematics students lack foundation skills in mathematics. There is a challenge in bridging the gap between primary and high school mathematics. Students lack the necessary mathematics skills needed at high school level and they are not able to cope. They therefore lose interest in the subject and this escalates in them not doing homework...

School D's teacher participants presented a similar view to that of participants at schools A and B in their assessment of mathematics students' knowledge and skills or lack thereof upon entering high school. Higgins, Harris and Stevens (2011) argue that there are concerns that institutions are more accountable for results than for their students' understanding of mathematics, implying that this will have detrimental outcomes for young people who study mathematics.

One participant at school D went as far as to suggest that the background knowledge of Grade 12 mathematics students at the school is inadequate and concluded that this dilemma was a common factor behind Grade 12 mathematics students not meeting the university entry level requirements for enrolment in medical, business and scientific studies. She commented as follows:

This is generally seen to be a result of the mathematics students not meeting the basic requirements to be promoted to the next level or grade. This presents a big challenge for mathematics teachers at the FET level, as mathematics teachers at this level do not have the time or capacity to remedy challenges faced by students who fail to have met grade level standards and have been promoted to the next level. This suggests that students' lack of knowledge from previous grades has made it difficult for mathematics teachers at the FET phase to achieve the expected outcome required at this level.

The mathematics Head of Department (HOD) at school E informed the researcher that the school did not offer mathematics prior to the year in which the interviews for this study were conducted. According to the teacher participants at this school, this was due to the low performance in mathematics at the school when it was offered about five years prior to the year in which it was re-introduced. Furthermore, the participants established that the demand for mathematics at the high school level in the area where the school is located is very low. This, one participant proposed, was a challenge as the school only offered mathematical literacy and therefore attracted low-performing mathematics students. One of the participants explained it as follows:

We only started offering mathematics literacy about two years ago, as in the past students performed badly in mathematics. The mathematics students we currently have at the school perform way below average. Our school is therefore probably one of the worst performing schools in mathematics.

Policy states that mathematics is a compulsory subject from Grades 1 to 9 (Vilette, 2017). Thereafter students have an option to either choose mathematics, mathematical literacy or technical mathematics. It has to be understood that when a school refers to 'not offering mathematics at school' this would imply that they only offer mathematical literacy and not pure mathematics.

5.3.6 Parental involvement and support

Parental involvement and support between the mathematics student and the parent were discussed as part of microsystems earlier in this chapter (see 5.2). For the purpose of this study, the current section focuses on the relations between home and school, that is, the mathematics teacher and those aspects that pertain to the mathematics student's home life, e.g. parental involvement and support.

Research has shown that the more actively involved parents are in the child's education, and the more mindful they are of the influence they exert on the child's attitude towards mathematics, the greater the chances are that the child will be successful in mathematics at school (Barnard, 2004). A study conducted by Epstein (1992, as cited in Anthony & Walshaw, 2007), showed that students performed better academically in mathematics and had more positive school attitudes if they had parents who were aware, knowledgeable and involved. This, however, does not appear to be the situation at school A. Teacher participants at school A stated that parents take a passive role in providing mathematics support to the students. This is highlighted in the following teacher response:

Some parents are not involved in the education of their children at all, especially in mathematics, as they are not able to assist the mathematics student. This could possibly be due to their lack of education. Parents are under the impression that it is the teacher's job to provide them (mathematics student) with extra support. Parents' responses are usually that we must deal with such challenges. Parents do not even collect their students' reports or attend parent meeting. They do not even encourage them to attend tutor programmes. This is a great concern to us.

The absence of parental involvement and support is a more serious problem at school B, where teacher participants pointed out that parents of the mathematics students largely demonstrate a passive role in the education of their students. This is illustrated by the following comments by two teachers from the school:

There are students' books that are constantly not up to date, and that is an indication that parents are not very involved.

The mathematics homework is never done. Parents of Grade 12 mathematics students only see to it that homework is done in the last term, as it gets closer to exam times. Then it is too late.

Another participant referred to the socio-economic background of the students as a possible justification for the lack of parental support.

Poverty and a lack of education probably play the biggest role in some parents' non-existing involvement. Some of them have no idea how to support their children in mathematics. They do not have the educational background, due to socio economic circumstances. It then becomes mainly the teachers' responsibility.

Similar to schools A and B, the results about parental involvement and support at school C confirm that the parents have limited involvement in the mathematics education of their children. One of the teacher participants at school C made the following remarks:

There is absolutely no involvement from the majority of parents. They do not even collect their students' reports; and this is for years. Parental support and involvement are non-existing. Parents do not have or make time to check the students' mathematics homework. If we request parents to attend parents' meetings, a lot of them do not attend.

Teacher participants at school C, as was the case with school B, agreed on the socio-economic background and education level of the mathematic students' parents as being a contributing factor to the parents' non-involvement in the mathematics education of their students. This lack of involvement presents the additional challenges of how the mathematics students perceive mathematics as a subject, in all probability producing a negative attitude towards mathematics. One participant stated:

Students come from impoverished areas. Their parents are not educated. They do not know how to support their students. It is for this reason that they have really very little interest in the subject.

Students' academic performance is closely related to their parents' educational level. Most students from poor socio-economic backgrounds do not have this privilege because many parents have inadequate education and are therefore unable to provide academic support for their students (Edward, 1995; Liu, 1996).

Rudnitski (1992) explains that it is important to keep in mind that low-income, culturally different parents have traditionally been marginalised through an inability to communicate with schools and the inflexibility of the school as an institution. Maluleke (2014) adds that this tradition has fostered feelings of inadequacy, failure and poor self-worth, which are cited as reasons for the low participation of parents from marginalised groups.

The findings from participants at school D and E depict a similar picture to that of participants at schools A, B and C. They consider parental involvement and support to be non-existent, depicting a lack of interest. This indicates that parents play no active role in mathematics education at schools D and E. The teacher participants expect the parents, at the very least, to motivate and encourage their children to do their mathematics homework. The teacher participants cite various reasons for the lack of parental involvement and support:

Reason 1:

Parents of the Grade 12 mathematics students at the school do not understand the importance of supervising their children's mathematics homework.

Reason 2:

They make no effort on their own to acquire assistance for the struggling mathematics student. They believe it is mainly the schools or the mathematics teachers' responsibilities.

Reason 3:

Absent parents are probably one of the biggest contributing factors of low mathematics performance as this implies that they have absolutely no interest in the child's academic life.

Reason 4:

The cycle of poverty in the communities in which the schools are located is evident in terms of education. Parents use their economic backgrounds as a justification for not being involved or supporting their children.

5.4 EXOSYSTEMIC LEVEL

This second part of the chapter focuses on the exosystemic level, which draws attention to the support and intervention programmes availed to mathematics teachers and students at the schools in this study by the WCED and its officials (the MCAs and school-based support teams), and other agencies for mathematics teaching and learning. This section will provide a broader understanding of what the participants perceived to be challenges in mathematics teaching and learning at the respective schools. The support and intervention programmes will be presented in relation to the challenges perceived by all the participants, at the different levels within Bronfenbrenner's ecological systems theory, as listed in Table 5.1.

Table 5.1: Challenges perceived by participants at various levels

Systems (levels) within Bronfenbrenner’s Ecological Systems Theory	Challenges perceived by participants on these levels
Microsystem	<ul style="list-style-type: none"> • Parental involvement and support (5.2)
Mesosystem	<ul style="list-style-type: none"> • Mathematics curriculum (CAPS) (5.3.1) • Resources (5.3.2) • Teaching methods (5.3.3) • (Non-)availability of mathematical support (5.3.4) • Primary school preparation for high school mathematics (5.3.5)
Exosystem	<ul style="list-style-type: none"> • Support by Western Cape Department of Education (5.4.1.1) <ul style="list-style-type: none"> ○ Mathematics Curriculum Advisors (MCAs) (5.4.1.1.1) ○ Curriculum support (5.4.1.1.2) ○ Resources support (5.4.1.1.3) ○ Teaching methods and content knowledge support workshops (5.4.1.1.4) ○ Support opportunities for students (5.4.1.1.5) • Other support programmes (5.4.1.2) <ul style="list-style-type: none"> ○ The Mathematics and Science Education Project (MSEP) (5.4.1.2.1) ○ The Strategy for Mathematics and Physical Sciences for Grades 8 to 12 (2012-2015) (5.4.1.2.2) ○ The SMILES initiative (5.4.1.2.3) ○ ZENEX Foundation (5.4.1.2.4) ○ AIMSSEC (5.4.1.2.5)

5.4.1 Support for mathematics teaching and learning

5.4.1.1 Support by the Western Cape Education Department (WCED)

5.4.1.1.1 Mathematics Curriculum Advisors (MCAs)

This section of the chapter focuses on the data obtained from one-on-one interviews conducted with the Mathematics Curriculum Advisors (MCAs) in each of the Districts in which the five high schools are located. The five high schools where the research was conducted fall under two education districts, Metropole South and Metropole North. In order to establish what type of support each of the five school in this study receive from the WCED, interviews were conducted with officials, in particular the MCAs responsible for providing support to mathematics teachers and students in the GET (Grade 8 and 9) and the FET (Grades 10 to 12) phases.

According to the KwaZulu-Natal Department of Education Curriculum Management and Delivery strategy (2012), one of the main responsibilities of the Curriculum Advisors (CA) is to check that teachers have all the necessary support material, e.g. content framework, textbooks, examination guidelines, exemplar papers and memoranda, past examination papers and memoranda, and training material on content. Leeuw (2002) refers to the nature of the relationship between the CA and the teachers as being reciprocal. In this regard, the teacher must be a willing participant of giving and receiving support from the CA within a certain period of time.

According to the (former) Department of Education (DoE, 2003), CAs are mostly located at the education district offices, where they form part of the education supervisory, support and monitoring system of teachers and schools. According to the Education Labour Relations Council (ELRC) Policy Handbook for Educators (PHE) (DoE, 2003), which details the roles and expectations required of CAs, curriculum delivery is considered to be the “core process” that defines the role of the curriculum advisor. Curriculum delivery, according to this source, centres on “guidance and counselling”, “monitoring” and “recording [of] progress”, and “curriculum development”.

The monitoring that CAs conduct refers to on-site support, which is the first line of support provided to mathematics students and teachers. This involves making daily visits to schools and moving into the classroom and observing the teaching and learning of mathematics with the intention of identifying any shortcomings on how to improve mathematics performance. Adedeji and Olaniyan (2011) agree that teachers should be monitored and frequently visited by the subject advisor and other district officials to assess whether they operate within the frameworks of the education requirements. However, there seems to be conflicting policy regarding classroom visits. Classroom visits are mandated by the Integrated Quality Management System (IQMS) of 2006, performance standard number 1-7. The South African Teachers Union (SADTU) however, noted that subject advisers do not form part of IQMS (Mnisi, 2016). Consequently, it is unclear whether CAs are allowed, or in fact do, visit classrooms to observe teaching and learning of mathematics with the intention of identifying any shortcomings on how to improve mathematics performance.

5.4.1.1.2 Curriculum support

It should be noted that CAs of any subject generally do not have a reciprocal relationship with students per se. Curriculum Advisors collaborate in a non-threatening manner between a district level and the school as a unit, and the head office management (KwaZulu-Natal Department of Basic Education, 2012). However, the support and assistance that the CAs provide to teachers are not only invaluable, but as a matter of principle have a direct impact on teachers' teaching and students' learning of mathematics.

School A falls within the Metropole South Education district, one of eight education districts within the Western Cape Province. On the scheduled interview appointment at the Metropole South District office with the MCA for school A, the researcher was informed that no MCA had been allocated to school A. A short and rather direct explanation was given, which pointed towards financial reasons, and also indirectly indicated a shortage of CAs for a number of schools. The departmental official did accommodate the researcher by illustrating and elaborating on the tasks which the MCA would usually be responsible for at school A. She presented information about systems that are in place, articulated in the following remarks:

We provide support to these schools by overseeing that the mathematics curriculum is implemented. This is done through monitoring, evaluation and looking at shortcomings on how to improve mathematics performance.

The departmental official could not provide specific information about the current situation of mathematics teaching and learning at the school. A general and broad description of CAs' responsibilities was given, mainly in terms of WCED's job description policies.

A study conducted by Adendorff and Moodley (2014) found that the visitation frequency by CAs to schools over the past four years was quite low, which is probably linked to the fact that currently there are altogether only 10 mathematics Intermediate and Senior Phase (ISP) Curriculum Advisors (CA's), servicing the ISP teachers across the Western Cape province of 1 458 mainstream schools. Six of the eight education districts have one ISP MCA each, with the remaining two districts having two advisors each. This means that each mathematics ISP CA on average has to serve approximately 146 mainstream schools. This scenario suggests that the number of ISP MCAs are inadequate in giving ISP mathematics teachers sustained and meaningful support. This is consistent with the 2009 review report's findings (DoE, 2009). The

above findings therefore also support the assertions made by the MCA at school A in terms of the shortage of MCAs at the school.

Unlike school A, school B, which is also in the Metropole South district, had an MCA allocated to the school. This MCA disclosed that the mathematics teachers at school B receive 'worked out' or planned mathematics syllabi. This means that the mathematics teachers are not required to rewrite their daily planning as suggested by CAPS. This 'worked out' syllabus provides them with daily and monthly planning of activities, which include prescribed timeframes for task completion related to the topics to be covered in the mathematics curriculum. This, according to the MCA, allows mathematics teachers at the school additional time to focus on the individual needs of the mathematics students in an attempt to improve mathematics teaching and learning. The MCA elaborated on support provided to mathematics teachers in various aspects related to giving advice with new developments, helping to achieve learning outcomes in mathematics, developing teaching materials, and providing advice on new teaching techniques.

School C is located in the Metropole North district. Like school B, the MCA for school C referred to a 'planned syllabus' for mathematics available to mathematics teachers in the GET and FET phase at the school. Here, too, mathematics teachers do not have to create their own daily, weekly and monthly planning. The MCA at school C made regular on-site visits to the school to identify the challenges teachers and students experience with the CAPS curriculum. The following information was revealed earlier by one of the teacher participants at school C:

The Education Department arranges several Reflection and Review meetings where mathematics teachers from various schools have the opportunity to share new and interesting ways to implement the mathematics curriculum.

School D is also situated in the Metropole North district. The MCA at school D provided a general explanation of the type of support provided to the mathematics teachers and students. She referred to the MCAs conducting regular on-site visits, where mathematics students are observed and questioned about the challenges, they experience in the mathematics classroom, including, but not limited to, the mathematics curriculum. This is in agreement with the core curriculum advisor duties, according to the DoE (2009), which include providing guidance and counselling to students on request. Notably, the MCA for school D voiced the following in relation to the level of support provided to mathematics students:

It becomes a challenge, due to time constraints and other factors; we are not able to provide the necessary support to the schools in the district. We do try our best, but unfortunately, we cannot reach all the schools.

The MCA at school D further acknowledged that Mathematics teachers do not receive the necessary support that they need and that it is often required of the teachers to 'work on their own'. This response from the MCA at school D confirms a possible shortage of CAs for schools in the Western Cape, as discussed in relation to school A above.

The MCA at school E, located in the Metropole North Education District like schools C and D, also provided a general description of how they assist mathematics students in the CAPS curriculum. Reference was made to on-site visits, monitoring and evaluations. Similar to the MCA at school D, the MCA at school E referred to conducting classroom observations in order to provide assistance to mathematics students and teachers, as well as to identify different types of intervention strategies. Follow-up visits by the MCA are conducted to see if mathematics students and teachers utilise and apply the information provided to them by the MCA at the school.

The general consensus from the MCAs at four of the five high schools is that they do the tasks expected of them to the best of their ability. These tasks include doing on-site visits, where they advise, assist with curriculum matters, identify and address content knowledge and teaching skills gaps, in addition to providing help to mathematics teachers to achieve set outcomes, developing teaching materials, new teaching techniques and doing regular evaluation thereof. The MCAs at the four schools expressed an awareness of the constraints placed on them due to the lack of CAs, not allowing them to completely fulfil the roles and responsibilities allocated to them. It can be concluded that this lack of support might have a direct impact on the quality of teaching and learning of mathematics, and the resulting achievements in the subject.

5.4.1.1.3 Resources support

The MCAs at four of the five schools (B, C, D and E), including the departmental official who discussed the situation at school A, pointed out that MCAs, being representatives and employees of the Western Cape Education Department, have as one of their core tasks the responsibility to ensure that the necessary resources are sourced and distributed timeously.

According to these MCAs, the following resources (shown in Table 5.2) were provided to the five high schools by WCED or donated by private organisations.

Table 5.2: Resources provided to schools

School	Resources provided
A	Data projectors; mathematics textbooks; additional mathematics learning material; past mathematics examination papers.
B	Smartphones; data projectors; laptops; printed material to mathematics teachers; mathematics textbook.
C	Mathematics textbooks, data projectors, past mathematics examination papers
D	Smartphones, document readers, and stationery. These resources were donated to the school from various private institutions, such as Vodacom and the University of Stellenbosch. The MCA does, however, indicate that the above donations occur on rare occasions, and that most private institutions that donate mathematics resources want the schools to commit to purchasing the resources on a regular basis.
E	Computers; extra Grade 12 mathematics learning material.

The resources indicated in Table 5.2 were not consistent with teacher and student participants' responses regarding resources allocated to their schools. It could not be established what the reasons were for these inconsistencies. The MCA at school D did, however, report that the Western Cape Government is apparently in the process of providing internet connectivity to all schools within a reasonable time frame. This strategy will focus specifically on providing broadband connectivity to every school in the Western Cape. According to this MCA, this strategy will:

. . . remove the digital divide, effectively integrate information and computer technology (ICT) into the classroom and ultimately enhance curriculum delivery.

5.4.1.1.4 Teaching methods and content knowledge support workshops

The departmental official representing school A mentioned that the WCED conducts and supports generic workshops for mathematics teachers. These are presented annually by various private mathematics and science organisations, which include the Cape Town Science Centre and the University of Cape Town. These workshops focus on content, and also provide mathematics teachers with various methodologies in the teaching of mathematics topics. This includes information on how to do basic mathematical (algebraic, geometric) calculations. It is then required of the teachers to select and utilise the most appropriate teaching methods that cater for the unique situation at each school. Notably, the official revealed that, from

their classroom observations and feedback, it can be concluded that many mathematics teachers do not apply the knowledge gained from these workshops.

The MCA at school B did not elaborate on any workshops or any other teacher training programmes available for mathematics teachers on teaching methodologies. The participant did, however, respond as follows:

Teaching mathematics is a complicated art that requires teachers to play many different roles. One important role for teachers is that of a researcher to reflect on and refine their own instructional and teaching practice. It can be a discouraging task, if faced with continuous changing mathematics curriculums, overcrowded classrooms, and an overload of administrative tasks. It is reasonable to infer that mathematics high school teachers need as much support as possible.

In a response that was identical to the response received from the departmental official who outlined the situation at school A, the MCA at school C claimed that the WCED offers annual teacher development and training seminars. According to the MCA at school C, this programme usually takes place over a period of two days, usually within school time (teacher substitutes are provided), and occasionally on consecutive Saturdays or mostly during the school holidays. Attendance of these teacher training seminars and workshops are not compulsory, and maybe close consideration should be given in making it compulsory for teachers to attend, especially if these programmes are related to subject content and curriculum delivery. Moreover, according to this MCA, schools are informed well in advance prior to the seminars. The programme entails providing mathematics teachers with practical examples of how to teach mathematics more effectively at the various school phases. He indicated during the interview that it was not possible to determine whether or not this programme is successful, as the mathematics performance of students at the school remains constant and can therefore not be considered as a determining factor.

The MCA at schools D and E, like the MCA at school B, did not refer to any specific support opportunities offered by the WCED on teaching methodologies or instructional practices. All three MCAs, however, mentioned that several workshops are conducted throughout the academic year on skills development, assessments, curriculum delivery and the Curriculum and Assessment Policy statement (CAPS). The MCAs at both schools D and E indicated that the assistance they provide to mathematics teachers are only upon request. This is mainly due to

time constraints because of the shortage of MCAs. However, both MCAs maintain that their main roles are that of monitoring and evaluation of classroom activities and the implementation of instructional practices according to departmental policies.

A 2009 review report's findings (DoE, 2009) on the implementation of the National Curriculum Statement state that teachers were asked to share their views about curriculum advisors. Respondents were asked to state when they had last had a subject-related conversation with the CA, discussing how, what or when to teach particular content. The majority of respondents, about 88%, answered in the negative. This meant that over the span of their teaching career as mathematics teachers, they had never had a face-to-face discussion with their CA on didactical matters. Only 12% of respondents indicated that they had subject-related conversations at a workshop without indicating the frequency thereof. Regarding the question as to whether there was a need to enter into such (didactical) discussions with the CA, about 17% of the respondents replied in the negative, while the overwhelming majority of the respondents (about 83%) were of the opinion that such a need did exist. Quite a few respondents emphasised the 'policing' role of the CA, because they saw him/her as someone who merely checks and finds fault instead of adopting a facilitating role. Many teachers described the current role of the CA as primarily being technician, with the focus on demanding unnecessary administrative tasks and 'box ticking' by teachers. The review also showed that there were too few CAs to give meaningful support to teachers. Notably, an overall observation of teachers was that they questioned the knowledge and skills of many of the CAs (Dada, Dipholo, Hoadley, Khembo, Muller & Volmink, 2009). The above responses clearly call for a further investigation into the role and job specification of CAs in general.

5.4.1.1.5 Support opportunities for students

The departmental official representing school A disclosed that the WCED offers mathematics tutoring opportunities for students during the school holidays, such as the Easter and the June holidays. According to the official, these opportunities are not provided at school A. However, the official did indicate that there are schools in the vicinity of school A where these opportunities are offered.

In May 2001, the Western Cape Education Department (WCED) introduced the Khanya project. This project was primarily aimed at poor schools, particularly those in previously disadvantaged communities. The main aims of the project were to remove the digital divide

between rich and poor schools and to empower educators, students and community members to use technology optimally to improve teaching and learning in identified learning areas such as mathematics, science, languages and history. The selection of schools for the Khanya project was based on those that possessed good management and sound academic results. In addition to this, the speed with which schools joined the project and received equipment was determined by the availability of provincial and donor funding.

Once a school qualified, a secure room (“the computer laboratory”) had to be found that was able to house approximately 40 computers per school, again meeting certain minimum criteria. In some schools, computers were installed in the classrooms. These computers provided the platform to support proprietary commercially available software developed by a local software company to deliver the mathematics curriculum. The software is called Master Maths (MM), a tutoring system that consists of the following components: (a) the MM tutor (a person) who oversees and coordinates students’ engagement with the system; (b) the tutor administrator, which is the software used by the tutor to control the functioning of the system; (c) the teaching/learning modules, including test modules, which students have access to through software called the M2 browser; and (d) module notes and worksheets that are intended to reinforce teaching and learning (see www.m2maths.co.za). The modules, accessible through the browser cover the mathematics curriculum from Grade 7 to Grade 12, and there are 293 teaching modules available (Louw, Muller & Tredoux, 2008).

Based on the above selection criteria, it was anticipated that certain schools were therefore excluded from the project. From the research conducted at the five schools, it can be concluded that only school A formed part of the Khanya project.

The MCA at school B had a different response to school A regarding the type of mathematics support provided to mathematics students at the school. He commented that the WCED, in collaboration with the Cape Peninsula University of Technology (CPUT), provides tutors to struggling mathematics students. Similar to the situation at school A, these programmes are only offered during the school holidays.

The MCAs at schools C and D had a similar perspective of the type of mathematics support offered and made available to mathematics students at the two schools, as stated respectively:

The Education Department sends mathematics teachers in the holiday periods to certain schools (venues) to help tutoring under-performing Grade 8 to 12 mathematics students. However, I think the focus should mainly be on Grade 11 and 12 mathematics students.

The MCA at school D corroborated with this statement:

The Education Department provides free tutoring for mathematics students and other subjects as part of a holiday programme.

The situation at school E is somewhat different to that at schools A, B, C and D, according to the MCA at school E. She infers that the school offers a mathematics online interactive support programme not only to mathematics students at the school, but also to mathematics students from other high schools in the area. This mathematics support programme, referred to as Telematics, is sponsored by the WCED and offers mathematics students the opportunity to ask questions to online mathematics facilitators regarding mathematical content that they experience difficulty with. They are able to communicate using advanced technology and up to date mathematics information.

The Telematics Project was initiated in 2009 as an intervention that sought to improve the National Senior Certificate results of the participating schools. This has expanded to include Grades 10 and 11 with a total of 821 schools around South Africa benefitting from the interactive afternoon satellite broadcasts of additional lessons which focus on difficult concepts in nine key subjects. These lessons are broadcast from a studio at the Stellenbosch University (SU) campus as part of the telematics service offered by the Centre for Learning Technologies. The one limitation of this project is that the schools should have sufficient broadband for streaming via YouTube. A possible explanation for why the other schools do not have this programme could be linked to the schools having no access to broadband, as inferred from the participants' responses. It should be noted that this programme serves as an aftercare programme, not only for the mathematics students at the school, but for all other students residing in the community.

Although not clearly determined from the responses, the general consensus amongst the participants was that they are not aware, in most instances, of the availability and presentations of mathematics support programmes at schools in the communities. What was

evident from the responses, is that most of the support opportunities were presented as 'after school' programmes and holiday programmes and that some of the students were not really keen on attending programmes during the holidays. This points to the mathematics students' and teachers' lack of understanding the important value of such programmes.

5.4.1.2 Other support opportunities

This subsection highlights other mathematics support opportunities offered by external providers, such as non-governmental organization (NGOs), private companies, and organisations outside the school environment. These support opportunities exist, but are not necessarily accessible to the five schools under study, as will be discussed in the next sections.

5.4.1.2.1 The Mathematics and Science Education Project (MSEP)

The MCA at school D indicated that she communicated to the school information on a mathematics support programme, the Mathematics and Science Education Project, a partnership initiative between the WCED and the University of Cape Town (UCT). Launched in 2005, MSEP aims to improve the quality of mathematics and science education in Western Cape high schools. MSEP was theoreticalised as a holistic intervention involving the following components:

1. Examination paper analysis, and the baseline results to assist the teachers with the prioritisation and sequencing of curriculum materials.
2. Practical and investigative skills training for teachers, coupled with content and theory within each theoretical area in the two disciplines, to address the finding that teachers lacked skills to design practical classroom work.
3. Collaborative teaching materials development to build the skills of teachers to design practical work.
4. Improved classroom practice through demonstrations and enhanced pedagogy, peer coaching, co-teaching and exam-focused assessment.
5. Lessons to address the evidence from the baseline study that the teachers lacked theoretical understanding of mathematical and scientific base principles.
6. A tutorial programme for students using student mentors.
7. The organisation of holiday schools for students to cover key concepts, examination papers and life skills.

8. The exposure of students to the worlds of science, engineering and mathematics to motivate them to participate in those fields and to excel within them.

The MSEP objectives are to:

1. increase the numbers of black African students taking high-level mathematics and science;
2. increase the number of black girls taking high-level mathematics and science;
3. support the sustainable enhancement of teaching and learning of high-level mathematics and science; and
4. conduct multi-disciplinary research in mathematics and science education at school level so that the provincial and national Departments of Education will have the urgently needed information on how to support schools in disadvantaged communities. Schools Development Unit (SDU), 2009.

5.4.1.2.2 The Strategy for Mathematics and Physical Sciences for Grades 8 to 12 (2012-2015)

In 2001, the Department of Education introduced the Strategy for Mathematics and Physical Sciences for Grades 8 to 12 (2012-2015). The strategy focused on three aims: (1) to increase participation rates in mathematics and physical sciences in Grades 10 to 12; (2) to increase the number of candidates passing mathematics and physical sciences in the National Senior Certificate examinations; and (3) to improve the quality of such passes in terms of increased numbers of candidates achieving A, B and C symbols (WCED, 2015).

In addition to the above aims, the strategy policy proposed support and development in mathematics and physical sciences at high schools in the following five key areas:

1. Schools
2. Teacher Support and Development
3. Resources and Support
4. Students
5. Monitoring, Evaluation and Advocacy

5.4.1.2.2.1 Schools

The DINALEDI initiative

In 2001, the Strategy for Mathematics and Physical Sciences for Grades 8 to 12 proposed the Dinaledi Programme to provide support in the form of physical resources and equipping teachers with the necessary pedagogical and content skills to improve the science and mathematics results in selected schools. The WCED wanted its schools to be part of the national Dinaledi initiative. The strategy involved selecting certain secondary schools for Dinaledi status that had demonstrated their potential for increasing student participation and performance in mathematics and science, and providing them with the resources and support to improve the teaching and learning of these subjects.

The schools selected offered mathematics and science in the higher grade and had small class sizes and competent mathematics and science teachers. The programme started with 102 schools in 2002-2004 and by 2008 this number had increased to a total (capped) of 500 (8% of secondary schools) (Department of Education, 2009:6).

A critique of this type of support programme is that only selected schools were identified to partake in this programme. This applied mainly to schools in previously disadvantaged communities. Part of the selection criteria entailed that schools should already achieve good results in mathematics and science, according to the Dinaledi schools' standards.

This type of mathematics support programme would thus not be applicable to the majority of schools who were underperforming in mathematics – schools that were clearly in need of this support. Findings suggest that none of the five high schools in this study are participating in this project. Possible reasons for this include the fact that the schools did not meet the required selection criteria, which was that the schools needed to have produced well above average mathematics performance results. The mathematics teachers at School A indicated that mathematics performance at the school ranks below 30% on average, while at School B the findings indicate that mathematics performance in Grade 12 is between 40% and 50%. At School C the majority of mathematics students in Grade 12 perform below 50%, at School D the average mathematics performance is below 40%, and performance at School E is the same as School B. Underperforming high schools in the Cape Flats area would not be able to benefit from such a project due to the selection criteria. Such projects place mathematics underperforming schools in an even more disadvantaged position in terms of the quality of mathematics education and the mathematics results produced.

The Dinaledi schools reported noticeable improvement in results, such as more students obtaining more than 50% in both mathematics and science in the higher grade (Zenex Foundation, 2012). However, several questions were raised about the assessment of the impact of the project on the basis of results, for instance, the difficulty of determining which factors are causally linked to the results (Dime Brief, n.d.). Is it the fact that these schools were selected for their performance that made them perform better, or is it because principals and teachers knew that there was interest in their performance and that results were being monitored that motivated them to do more?

5.4.1.2.2.2 Teacher Support and Development

The strategy intended to develop mathematics teacher content knowledge, skills and pedagogy in the teaching of mathematics. This was done through short workshops that focused on aspects of the mathematics curriculum and lessons in Telematics (mathematics online interactive computer programme). This programme was initiated by the WCED in collaboration with universities, such as the School Development Unit (SDU) at UCT, the Institute for Mathematics and Science Teaching at the University of Stellenbosch (IMSTUS), the Association of Mathematics Educators of South Africa (AMESA) and various NGOs. Specific objectives for FET mathematics teachers included interventions and training in:

- content knowledge and theoretical understanding;
- teaching strategies and methodologies, effective use of Information and Communication Technologies (ICT) to enhance teaching and learning;
- planning to ensure curriculum-completion; and
- motivation and interest for both students and teachers.

Mathematics teachers at two of the five schools that participated in the study indicated that they attended workshops similar to the ones mentioned above that was initiated by the WCED. According to teachers from one of the schools, the advantages of attending these workshops included the sharing of information, and the technological advantages of using Telematics in changing the students' attitude towards mathematics. With specific reference to the objective of providing training and intervention in curriculum completion, this objective seems frivolous, as all participants at the five schools referred to structural challenges in the mathematics curriculum. This challenge was raised by both the mathematics teachers and students at four of the five high schools. According to the participants, at these WCED

workshops, focus was given to the structural components of the mathematics curriculum that needed to be revised, and/or intervention and training strategy programmes needed to focus on these aspects of the mathematics curriculum.

Mathematics students at two of the schools (D and E) indicated that mathematics teachers lack effective teaching methods. The student participants that were at the same high school doing mathematics since Grade 8 stated that many of the mathematics teachers simply teach the subject in a manner by merely stating information (steps and procedures), and no real emphasis is placed on problem solving skills. Apart from this, there is a general notion amongst the student participants at these two schools that 'we (the students) are teaching the teachers mathematics'. This implies that the mathematics students are aware that the mathematics teachers are not confident in teaching the subject. The student participants clearly indicated that they are not in a position to provide detailed reasons for the teachers' lack of confidence in teaching the subject. The student participants at these schools indicated that this has an enormous impact on their understanding of the mathematics content, and also their performance in the subject, thus indicating the relevance of intervention and training strategies with regard to improving teacher methodologies.

5.4.1.2.2.3 Resources and Support

The Strategy for Mathematics and Physical Sciences for Grades 8 to 12 (2012-2015) had set the following targets in terms of providing resources to schools that offer mathematics as a subject:

- A mathematics textbook for each of the mathematics students at high schools in the country.
- Mathematics students should receive a calculator, question papers and memoranda of previous Grade 12 mathematics question papers.
- ICT – in the form of software and hardware, digital resources, broadcasting Telematics lessons to schools and integrating mathematics teaching and learning with the WCED and University of Stellenbosch.
- Using radio broadcasts and media for advocacy.

The findings revealed that four (A, B, C and D) of the five high schools in this study have no technological resources such as working computers and have no internet access. School B has no projectors and mathematics students have no calculators. Only one school (E) in this study

makes use of the Telematics online programme. Furthermore, participants at all the schools indicated that they also lack mathematics textbooks. The data undisputedly shows that the five high schools in this study experience a severe lack of technological resources as well as mathematics textbooks.

5.4.1.2.2.4 Students

The Strategy for Mathematics and Physical Sciences for Grades 8 to 12 (2012-2015) formulated the following goals for mathematics students as a means of providing support in the learning of mathematics:

- Provide supplementary tuition (Saturday or holiday classes).
- Broadcast Telematics lessons to poorly performing schools.
- Supply past papers and other resources and teacher training as required.
- Expose students to high-level problem-solving exercises, including participation in Olympiads and competitions.

Mathematics students from one high school (D) indicated an awareness of the supplementary tuition programmes that take place in the school holidays. Mathematics students at the remaining four high schools (A, B, C and E) stipulated otherwise, indicating a possible lack of communication of valuable information between the relevant education department and the mathematics teachers at these schools who in return do not or cannot convey this information to the mathematics students.

With reference to the Telematics interactive online mathematics support programme, students at only three (B, C and E) of the five schools indicated an awareness of this programme. The supply of past examination papers is limited to schools B and C. The three remaining schools appear to not have been receiving past examination papers. The education department concerned has thus not satisfied this goal at three of the five high schools in this study. The mathematics teachers at schools A and E explained that the strategy's goal of ensuring participation of the five high schools in Olympiads and competitions has not been fulfilled.

5.4.1.2.2.5 Monitoring, Evaluation and Advocacy

According to the Strategy for Mathematics and Physical Sciences for Grades 8 to 12 (2012-2015), departmental officials, in particular the MCAs, are responsible for monitoring

curriculum delivery in the classroom to ensure that the content, level and pace of the CAPS curriculum in mathematics are met. This is achieved through:

1. site visits and interaction;
2. deployment of effective monitoring and evaluation officials; and
3. customised monitoring, evaluation and reporting instruments.

The departmental official and MCA allocated to two of the five high schools (A and E) indicated that they execute on-site visits at the school, providing mathematics teachers with information on intervention strategies on how to deal with underperforming mathematics students, as well as observing classroom practices with the intention of improving mathematics performance at the schools. In addition, they also ensure that the mathematics curriculum is implemented through monitoring, evaluation and professional development. These specific responsibilities appear to have not been carried out at the remaining three schools (B, C and D). Mathematics teachers at School D indicated that the MCA allocated to the school is 'not visible'. The MCA allocated to school D confirmed this and claimed that the Education District has a shortage of personnel and is therefore not in a position to provide the necessary support to school D. Evidently, this implies a shortage of departmental officials, indicating a challenge in the execution of the goal to deploy effective monitoring and evaluation officials. This challenge could possibly also have an impact on the mathematics results at school D.

Other support opportunities offered but not accessible for mathematics students and teachers at the five high schools under study include:

5.4.1.2.3 The SMILES initiative

In 2009, the University of Stellenbosch initiated the Science and Mathematics Initiative for Students and Educators (SMILES) schools' partnership project. University-based facilitators embarked on class visits at five historically disadvantaged high schools and 10 primary schools in the Cape Winelands District with the objective of identifying teacher needs, co-teaching and offering professional support over a three-year period (Ndlovu, 2011). One critique and limitation of this initiative is that the selection criteria excluded those schools that had an overall pass rate of less than 60%. Schools that underperform need such an initiative, more so than schools that are performing above average.

5.4.1.2.4 ZENEX foundation

The Zenex foundation was formally established in 1994. Two of the main objectives of the organisation are to increase the number of professionally qualified teachers in mathematics; and to improve learner academic performance in mathematics and science. These objectives are particularly aimed at black (African, coloured and Indian) students and teachers from disadvantaged background. The intention is to facilitate their pursuit of careers related to mathematics and science following tertiary studies in these fields (Zenex foundation, 2006-2011). Three intervention strategies were identified in terms of the implementation of the programme:

1. School management teams receive training in instructional leadership and curriculum delivery.
2. Teachers are grouped in phases and by learning areas to develop their content knowledge of mathematics and improve classroom practices.
3. The student programme which is implemented at the FET level focuses on assisting students to improve their performance in mathematics to gain access to bursaries for tertiary enrolment.

The five high schools in this study are not able to benefit from such a programme as the selection criteria for enrolment in this programme requires mathematics students in the FET level to have obtained at least 50% in both mathematics and English. Findings on the mathematics performance of all of the five high schools reflect mathematics results below 50%. Similar to the above-mentioned support opportunities (Dinaledi, SMILES), this programme needs to be reviewed in terms of not providing mathematics support and assistance to underperforming mathematics students in previously disadvantaged areas.

5.4.1.2.5 AIMSSEC

The African Institute for Mathematical Sciences Schools Enrichment Centre was established in 2003. The main objective of the AIMSSEC programme is to advance educational opportunities for disadvantaged communities, introduce new skills to teaching and learning mathematics and to raise the standards of mathematics teaching in South Africa. This is achieved through presentation of workshops and development courses for mathematics initiated by the Universities of Stellenbosch and Fort Hare. However, the five high schools in this study were

not able to benefit from this programme as originally it was aimed at schools in rural areas in the Eastern Cape.

5.4.2 Strengths and limitations of ALL the mathematics support opportunities

Mathematics support opportunities should be interpreted as services offered to students in addition to their regular programme of mathematics teaching. It should encompass a wide range of provision such as mathematics workshops and mathematics help centres that offer tutoring services. However, the level and degree of support opportunities may not be as effective as it was ideally planned to be, for various reasons. As a general observation in this study, these reasons include, but are not limited to, aspects of:

1. The level of interest.
2. Access to the programme.
3. Relevance of the information on offer to their specific needs.

One component of this study was to identify the strengths and limitations of mathematics support opportunities on offer at each of the respective high schools in the study. The following table 5.3 provides details of mathematics support opportunities available at each of the five high schools (for teachers and students), as indicated by the participants. In this table, the heading “Other support opportunities” includes those support that are on offer, but not necessarily accessible to the participants at schools in this study. From this information, the appropriateness of *ALL* these support opportunities can be determined.

Table 5.3: Strengths and limitations of mathematics support opportunities

School	Teachers/students	Offered by schools/WCED	Access to support opportunity/programme	Organisation /Provider	Type of support opportunity	Strengths of support opportunity	Limitations of support opportunity
A	Teachers	Yes	Yes	WCED	Generic workshops - development & teacher training seminars	<p>Teachers are trained and exposed to various mathematics teaching methods with the latest development in mathematics instructional methods.</p> <p>The sharing of information, and the technological advantages of using Telematics in changing the student's attitude towards mathematics. Provides intervention skills for curriculum completion.</p>	The school principal informs them too late about the workshops, thus providing them with limited time to respond to such invitations.
A	Students	Yes	No	Master Maths	Computer installed mathematics software & offered in a private capacity as a mathematics tutoring programme	<p>School capacity- provides module notes and mathematics worksheets.</p> <p>Covers the Mathematics curriculum- CAPS</p> <p>Private capacity- one on one tutoring services,</p>	<p>Interrupted/No internet connectivity at school</p> <p>No computer lab support structures in place</p> <p>Requires private fees/funding</p>

						including the school capacity advantages.	
C	Students	No	No	Mathematics magix	Mathematics software application	A user-friendly computer application that provides easy, medium and difficult levels for both Practice and Test sessions in mathematics for all school grades. It tracks history of previous tests taken by an individual and displays level wise high scores along with average time taken per question. Gives scope for improving mathematics skill-sets of an individual.	Requires private fees/funding
A	Students	Yes	Yes	UWC	Holiday tutoring programmes-for mathematics students	The service is free. Provides mathematics support to students that are struggling in maths. Covers content in the Mathematics curriculum-CAPS.	Tutors' teaching methods can be too advanced for struggling students. Different teaching methods can be confusing to the students.
A	Students	No	No	Study Buddies	Multisensory (text, voice & video operated) computer/phone/i-pad learning software	Step-by-step instructions for students in all school grades. Offered in English & Afrikaans	Requires private fees/funding

						Approved by Department of Education Follows the mathematics curriculum-CAPS	
C	Teachers	Yes	Yes	WCED-Reflect & Review meetings	WCED teacher training workshops	Mathematics teachers share best practices particularly about the mathematics curriculum.	Ideas shared amongst mathematics teachers from various high schools are at times not applicable to mathematics students that are underperforming and come from impoverished backgrounds.
B, C & E	Students	Yes	Yes	Telematics (Vodacom)	Mathematics online interactive computer programme	The presenters explain core concepts and address problem areas in which students had experienced difficulty in previous examinations. All the broadcast is available on DVD or as part of the online video library, which is a powerful tool the teachers can use for exam revision. A major factor in the success of the project is	No Internet access/broadband connectivity Need to be expanded to more schools/areas with struggling mathematics students.

						the dynamic interaction that can take place between the presenters, working from the broadcast studio at Stellenbosch University, and the students watching via satellite or live Internet streaming all over South Africa. The students can ask questions via an interactive web page.	
E	Students	No	Yes	Shawco	Saturday classes & workshops	Provide students with curriculum support in core academic areas, such as maths. Students have access to the University of Cape Town's resources.	Requires private fees/funding
			Other support opportunities				
A,B,C,D & E	Students & Teachers	Yes	No	Dinaledi Programme	Support in the form of physical resources & professional development programmes and workshops for mathematics teachers to equip teachers with	Noticeable improving results in mathematics for the students at the schools	The selection criteria allow for exclusion of those schools that are already low performing in mathematics

					content knowledge & pedagogical skills.		
A,B,C,D & E	Teachers	No	No	SMILES initiative	Training & professional development for mathematics teachers	The attitude towards mathematics & other subjects has improved, notably more than the mathematics NSC exam results.	The professional development training of the teachers was not attached to any accredited programme or short course. No real noticeable improvement in mathematics performance from students.
A, B, C, D & E	Students, Teachers & School Management	No	No	Zenex Foundation	Skills development & Training in mathematics provided on three levels: <i>school management</i> - instructional practices & curriculum delivery <i>teachers</i> - content knowledge of mathematics and classroom practices <i>mathematics students</i> - various learner	Improving mathematics results	Programmes are not available in the Western Cape

					<p>placement from previously disadvantaged schools to high performance independent schools</p> <p>Offer/Sponsor bridging courses for Grade 12 mathematics/science students to improve mathematics results for successful enrolment of mathematics /scientific professional qualifications at a tertiary institution.</p>		
A, B, C, D & E	Students & Teachers	No	No	AIMSSEC	<p>Presentation of workshops and professional development courses for mathematics teachers</p>	<p>Distribute teaching and learning resources</p> <p>Create an interactive school mathematics community</p> <p>Encourage further study of mathematics and mathematics education</p>	Programmes not available in the Western Cape

5.5 CONCLUSION

The foregoing sections presented an insight into the challenges mathematics students and teachers experience at five previously disadvantaged selected high schools in Cape Town. Findings were presented and discussed in terms of the types of support and support opportunities mathematics students and teachers have access to and utilise, and those offered by the WCED in partnership with various universities in Cape Town. All other student and teacher mathematics support programmes made available by the WCED and other providers were made known in this study. The aim of this was to create an awareness of such mathematics support opportunities.

The strengths and limitations of these mathematics support opportunities were highlighted as a means of determining the appropriateness of these support opportunities as perceived by the participants in this study. Mathematics support initiatives and projects of education departments were critically examined and analysed with the intention of identifying gaps in these support opportunities.

In Chapter 6, conclusions and recommendations are made on all the findings stated in this chapter in an effort to answer the second research question which was aimed at:

Identifying the most appropriate mathematics support opportunities for mathematics students and teachers at high schools in the Cape Flats area in Cape Town.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The objective of this chapter is to present conclusions and recommendations, based on the findings discussed in the previous chapter. This is done in an attempt to establish effective and appropriate support opportunities for mathematics students and teachers at previously disadvantaged Cape Town high schools through an interpretation of the findings presented in Chapter 5. The purpose of this research was to:

- Increase the understanding of challenges in mathematics teaching and learning at selected schools in disadvantaged communities.
- Identify the support available for mathematics teachers and students.
- Identify which support opportunities teachers and students at the selected schools have access to, and utilise.
- Identify the strengths and limitations of the available support opportunities, in order to establish which of these support opportunities are appropriate for these schools.

This study arose from a need to *improve achievement in mathematics* through *providing alternative support opportunities*, particularly in schools in previously disadvantaged communities, identified through their persistent poor performance in mathematics. The literature review and theoretical framework presented in Chapters 2 and 3, respectively, together with the methodology and research design set out in Chapter 4, provide a useful framework to guide the interpretation and integration of the key findings in this chapter.

In Chapter 2 it was demonstrated how Bronfenbrenner's ecological systems theory provides a theoretical framework for the investigation of the interaction of three of the four systems relevant to mathematics education. These four systems emphasise the relationships and interactions students and teachers have in their immediate environment, e.g. children's interactions with their parents; interactions between home and school; and interactions between teachers and students with the larger social and professional environment. For the purpose of this study, the first two systems focused on the challenges experienced in mathematics education at the five schools as a result of the above-mentioned interactions. In the third system, attention was drawn to the support opportunities provided to mathematics

students and teachers by the relevant education departments and external agencies; and the impact of the resources of the society at large on the teaching and learning of mathematics.

The findings in Chapter 5 were obtained mainly from the qualitative and quantitative research undertaken for this study. The data arising from the qualitative research served as the primary source of information for the findings, while the data arising from the quantitative research served to provide supporting evidence for certain aspects of the qualitative data.

6.2 CONCLUSIONS AND RECOMMENDATIONS

6.2.1 Parental support

The data in the findings in the five high schools with regard to parental support, which formed part of the micro– and mesosystem, revealed three fundamental conclusions.

1. Firstly, students perceive that their parents encourage them to do well at school and hold high expectations. Parents, on the other hand, appear not to be actively involved in their children’s academic life. Nineteen of the twenty mathematics teacher participants supported the latter findings. They were of the opinion that parents have limited understanding of what parental involvement entails. According to the teacher participants, this is not only reflected in the parents’ attitudes towards the mathematics teachers, but also in the passive role they undertake in their children’s education.
2. Secondly, it appears that parents are not fully informed about the career options and requirements needed for obtaining a qualification in a specific field of study at the tertiary education level, and are therefore not able to guide their children in making these decisions.
3. Lastly, even though 69% of all the mathematics students perceived that their parents consider extra mathematics tuition to be essential, only 10% of mathematics students are able to benefit from private tuition, largely due to the inability of their parents to pay for such tuition.

It is recommended that in the beginning of an academic school year, the relevant department of education, in collaboration with the relevant schools and other private organisations and local universities, present a compulsory workshop to parents of all students in high school.

These workshops can provide practical examples of how parents can get involved in their children's academic life. This can be done through information sessions, distribution of reading material and resources on parental involvement and the importance thereof. The following issues could be addressed:

1. The importance of homework.
2. How to support the student.
3. The importance of passing with a Bachelor's pass.
4. Subject and career choices.

To demonstrate commitment, a written agreement should be made between all relevant stakeholders concerning the above matters, thus encouraging accountability and, most importantly, active involvement in the students' academic life to the benefit of the student. Parents can get involved in volunteer projects to support teachers, for example, by utilising a community hall to help students with their homework; or have mathematics or reading clubs as a concerted effort to support their children (Walker, Chang, Vera-Hernández & Grantham-McGregor, 2011). Regular parent-teacher meetings can be held to discuss innovative and creative ways to establish a collaborative partnership between the school and the community. For these types of programmes to be successful, parents must make a mind shift from placing all educational responsibilities on the school (teachers) to taking the role of partners to the school. This includes families creating a home environment that supports children as students.

It is recommended that schools assist parents with information on how to create a conducive learning environment at home. This can be achieved through sharing information related to parenting approaches which include a child's health, nutrition, discipline and adolescence. In return, the schools should endeavour to assimilate and incorporate the students' family life orientation into what is taught in the classroom. The benefit of the parenting type of involvement to the student include improved discipline, improved school attendance, increased learning time and understanding the importance of schooling later in life (Epstein, 1995). This involves two-way information sharing between the school and the parents regarding school programmes and students' progress. Schools are encouraged to devise various modes of relaying information between the school (teachers) and the family (students). Parents should be encouraged to contact the school at the onset of each grade entry. Various forms can be adopted which may include periodical parent-teacher meetings,

telephone conversation and messaging, social media platforms and students' report cards. This creates a positive communication link which forms the basis of discussion in case the student develops problems later in the year (Gwija, 2016).

The home environment is truly the first "school" that all students attend as parents actively engage with children during their growing life. In this respect, it is required of schools to assist parents with interactive activities which enhance learning activities similar to those taught in school. These activities could include: assisting parents to understand some activities in the school curriculum which their children require during their schooling progression, develop a means of informing parents on how to monitor their children's performances and behaviour, and educating parents on how to train their children to set and achieve appropriate career goals and on how to choose school programmes that best fit the student's schooling interest (Mahuro, Hungi & Lamb, 2016). Van Deventer and Kruger (2009) confirm that parent involvement has a considerable effect on the quality of students' experience of teaching and learning in the school, and in their academic results. Therefore, students perform better in school based on a range of social and academic indicators when schools reach out to families and communities (Glanz, 2006).

A typical way of how a parent can get involved in school activities is illustrated in the next example. Parents with higher academic and professional qualifications may be invited to the school to provide assistance using their respective expertise and knowledge to boost teaching and learning. Similarly, parents who do not have qualifications or higher degrees in any specific field, can be asked to assist the school using their manual skills in maintaining school buildings, working in the school garden, among other tasks, that will benefit the school (Xaba, 2012). In the United States of America (USA), federal and state policies have elevated parental involvement in schools to a national priority. This should also be emphasised in South Africa. Although the parents' role in their children's education is promoted in the White Paper 2 of 1996, Mncube (2009) claims that "at some schools in South Africa, parents are not yet playing their full role as governors mandated by legislation", that is the South African Schools Act No. 84 of 1996.

6.2.2 Career guidance

As students move towards high school, families often assume that children and counsellors will work together to establish a career and post-secondary education plan, so they believe their role as parents decreases (Amatea, Daniels, Bringman, & Vandiver, 2004). In schools with large numbers of students, which is usually the case for schools in previously disadvantaged areas and/or in poor socio-economic communities, school counsellors might not meet the demands of assisting all students in career choices. Therefore, many students complete high school ignorant of higher education choices, career processes and corresponding decisions (Joseph, 2012). Some of these students tend to enrol in colleges or universities hoping that time will allow them to make a decision and solidify their future. As a result, many of these students waste time, money and effort, unsure of what to expect from life (Amatea et al., 2004). As an additional measure, the relevant education departments could invest in employing additional school counsellors for the purpose of career guidance, particularly from Grade 10 to Grade 12.

6.2.3 Private tuition

It is a known fact that private tuition in general is rather costly, particularly for those from poor socio-economic backgrounds, and those that are in dire need of support to improve their mathematics results. Private tuition in South Africa is largely unregulated by government, but is overseen closely by parents, students, teachers (in the industry) and franchisors (who need to keep their reputations high and show results). Whilst it is relatively easy for individuals to enter the field of extra tuition, and while this does have advantages, it can also result in unqualified operators who might not be able to provide a reasonable service (Centre for Development and Enterprise, 2013). As for the WCED and DoE, mathematics support collaboration made available to students at the schools in this study, such as holiday mathematics tutoring programmes, the mathematics teachers at these schools should not only recommend that low performing students in mathematics attend these mathematics tutoring sessions, but also motivate to make attendance compulsory to the identified students. This type of action will encourage active participation and accountability from all stakeholders in the mathematics students' futures. In addition, such participation could form part of the agreement by parents referred to in section 6.2.1 (Parental support).

6.2.4 Mathematics Curriculum (CAPS)

A challenge recognised by both the 100 mathematics students and 20 teacher participants from the five schools, is the Mathematics Curriculum and Assessment Policy Statement (CAPS), in particular the structural component of the mathematics curriculum. Distinct reference is made to the unrealistic timeframe given to complete the content in the mathematics curriculum. The question remains whether time allocated for mathematics lessons is sufficient for students to master the mathematical concepts. Incongruously, the CAPS curriculum was introduced and implemented with the objective of providing more time for teaching and learning. The curriculum documents clearly stipulate what topics are to be covered in particular time frames, and details of the content to be covered, all according to a year plan which shows both the sequencing and pacing of topics across Grades 10, 11 and 12. According to Umalusi, the Council for Quality Assurance in General and Further Education and Training envisages the sequencing and pacing of topics to be problematic – particularly if the suggested pacing and sequencing is enforced – in particular for struggling students and those that need individual attention (Umalusi, 2014).

Apart from the above challenges regarding the mathematics curriculum, the mathematics teacher participants at two of the schools mentioned that the geometry and trigonometry content in the CAPS curriculum are presented in an excessively abstract manner. Thus, referring to the absence of concrete (*visible*) examples, Eggen and Kauchak (2000), interpreting Piaget's work (*developing from concrete to abstract thinking*), contend that middle school teachers may assume that their students can always think logically in the abstract, yet this is often not the case. The teaching of Euclidean geometry is a good example of students often being introduced to abstract concepts too soon. Teachers start teaching theorems, their proofs and their applications and expect students to argue logically on a deductive level. However, Usiskin (1982) points that geometric thinking, as described by the Van Hiele husband and wife team of researchers, develops in five stages or on five levels. These levels are sequential, i.e. to operate successfully on any level, a student must have mastered the previous level(s). Failing to do so, will result in stagnation in the development of geometric thinking, and a resultant inability to operate on a higher level. Teachers often believe they express themselves clearly and logically, but their reasoning is not understandable to students who are still at lower levels (Vojkuvkova, 2012). The progress from

one level to the next is more dependent upon appropriate experiences provided through proper instruction than on age or maturity. The Van Hiele levels are widely recognised in the successful teaching and learning of geometry.

The first Van Hiele level is 0 (*visualisation*), where the focus is on *basic visualisation* or *recognition*. At this level students use visual perception and nonverbal thinking in an effort to recognise geometric figures by their shape as “a whole” and compare the figures with their prototypes or everyday things (“it looks like a door”), and categorise them (“it is / it is not a...”). They do not identify the properties of geometric figures. At the next level (level 1), referred to as the *analysis* level, students start analysing and naming properties of geometric figures. Students are encouraged to think that all properties are important, with no emphasis yet on the relationships between properties. Level 2 is the *abstraction* (or informal deduction) level. At this level students distinguish relationships between properties and among figures. They can draw logical maps and diagrams. Level 3 is the *formal deduction* level. Here students are able to provide deductive geometric proofs. They identify which properties are disguised by others. Students have a good understanding of the role of definitions, axioms and theorems. On the next level, 4, named *rigour*, students establish understanding of the operations of mathematical systems. They are able to describe the effect of adding or removing an axiom on a given geometric system.

Notably, as an additional challenge, CAPS suggests only 12.5% of class time for Euclidean geometry, while simultaneously suggesting that it accounts for 16% of the weighting in terms of marks during assessment (Umalusi, 2014). Since Euclidean geometry is so cognitively demanding, it is recommended that it needs to be taught in a more concrete and practical manner (including everyday life experiences and applications), being less prescriptive in terms of the content covered within a predetermined time frame, and, therefore, also requiring more time for teaching and learning.

6.2.5 Resources

6.2.5.1 Physical resources

6.2.5.1.1 Mathematics textbooks

6.2.5.1.1.1 Content

Mathematics textbooks for all grades should consist of content that corresponds with the Mathematics CAPS curriculum and should be practical in terms of its usefulness. Valverde et al. (2002) stresses the value of mathematics textbooks by conferring that the structure of mathematics textbooks is likely to have an impact on actual classroom instruction. The form and structure of textbooks in all likelihood advance a distinct pedagogical model that embodies a plan for the particular succession of educational opportunities, indicating that the pedagogical model only becomes effective when the textbook is actually used. The textbooks provide the students with the content of their curriculum, and exercises and practice material to assist students in grasping that content. The purpose of the textbook is therefore to supplement what the teacher covers during class time (Malgas, 2013). It is therefore recommended that the content of the textbooks should be regularly reviewed and updated to correlate with curriculum changes and users' feedback. This could be done through continuous consultation with the mathematics students, subject teachers, the authors of the mathematics textbooks and all other officials usually involved in such a process.

6.2.5.1.1.2 Condition of the mathematics textbooks

According to Stein (2017), the lifespan of a textbook is five years. This means that students must return the textbooks to their schools at the end of each academic year, and the textbooks will then be provided to the incoming class in the following academic year. This process should take place in a five-year cycle. Due to the relevant education department's budgetary constraints and cost of textbooks, it is recommended that subject teachers take responsibility and accountability for the textbooks within the classroom. Subject teachers need to have monitoring systems in place for the distribution and record keeping of textbooks within the classroom. Students should not be allowed to take textbooks home. If needed, copies can be made of the content in these textbooks. Mathematics textbooks should only be utilised in the classroom under the teachers' supervision. Although many schools have adopted this method, there should be effective and compulsory monitoring systems in place

to keep track of textbooks in students' possessions. Similarly, students need to be held responsible for the condition of the textbooks when in their care and consequently be penalised for vandalising and purposely damaging government property.

6.2.5.1.1.3 Accountability for mathematics textbooks

From the findings in Chapter 5, it is recommended that the relevant department of education reviews issues surrounding the procurement and use of mathematics resources such as textbooks, and increases its capacity to supply the demand. The implementation of the new curriculum led to considerable difficulties due to a lack of delivery of textbooks and workbooks to students. Against this background, it is important to note that the Supreme Court of Appeal has ruled that every learner is entitled to his or her own textbook for every subject (South African Legal Information Institute, 2015). Each province has a different model for procurement and delivery, but they all have to adhere to the nationally compiled catalogues and addendum catalogues (Stein, 2017). Three main systems of procurement of textbooks exist: a centralised procurement system, a school-based procurement system, and a hybrid procurement system (South African Human Rights Commission, 2014).

Schools in the Western Cape Province opted for a school-based procurement model. Schools were required to complete requisitions for quantities of Learning and Teaching Support Material (LTSM), such as textbooks, and submit these to the WCED. This meant that schools were afforded the opportunity to select which books they would like to order, and the WCED would transfer funds directly to the service provider. It should be noted that the WCED issued a multiple-source tender for supply of these books directly to schools (Parliamentary Monitoring group (PMD), 2013). It is recommended that selected administrative staff at schools receive the ordered textbooks and keep an operational inventory of it, allocating and distributing it to the relevant subject teachers. Accountability and responsibility for the textbooks at school level are emphasised in this regard.

Furthermore, an investigation conducted by the South African Human Rights Commission (SAHRC) (2014) highlighted some of the main challenges that contributed to the lack of textbooks at schools. For the purpose of this study, certain challenges reflected by the research questions in this study were identified. These are briefly discussed below.

Not all schools are capable of making accurate projections of the number of students that would enroll in each grade in the following academic year. In some instances, this reflects the schools' administrative staff's inability to monitor and keep record of administrative matters. However, in light of last-minute enrolments and changes of subject choices, some variance appears to be part of what the system needs to cope with, but is currently not capable of. Monitoring and information systems need to be regularly reviewed, and consideration should be given to the employment of additional administrative staff strictly for these purposes. Currently these responsibilities are given to school principals or any available administrative staff, who at times do not do a thorough review or delivery of textbook to the correct grades and classrooms, due to other responsibilities.

The SAHRC (2014) report also revealed that school principals (who are currently responsible for placing orders) do not always order books timeously, and at times deliberately fail to report shortages or incorrect deliveries, which they do not take responsibility for. School principals have many responsibilities; accountability and the confirmation and signing off of textbook orders should be given to selected management staff at the school level.

Other challenges include the inefficiency of schools to adhere to budgetary allocations or directives issued to them. In such cases, textbooks are not delivered to the schools. Although the national Department of Basic Education implemented electronic systems to increase efficiency of the process of allocation and distribution of textbooks, there continues to remain loopholes in these systems, which all point to human error.

Other notable challenges include the fact that the change in curriculum had a significant negative impact on small and emerging publishers, as only a limited group of providers were selected as suppliers of textbooks (SAHRC, 2014). According to the SAHRC's report, too often corruption or irregularities are overlooked and not properly investigated. For this reason, independent investigation authorities should handle such matters with priority and have recourse actions in place.

It is evident that a reciprocal relationship exists between the management of school infrastructure and the shortage of textbooks. Relevant education authorities should give attention to existing school infrastructure by identifying any breakdowns within the system,

with an aim to urgently improve on any matters that negatively affect the teaching and learning of students.

A functional system of ordering mathematics textbooks, and the accountability thereof at schools at management level, must be made a priority. This will, in all probability, have an immense impact on the timely and definite attainment of these resources that contribute immeasurably to the success of mathematics education at all schools.

6.2.5.2 Technological resources

Digital and electronic resources remain a challenge at all five of the high schools, as pointed out by the participants. Several of the participants at four of the five schools referred to having a dearth of technological resources, such as projectors, access to the internet, updated computers and mathematics computer software. Kerrigan (2002) found the benefits of using mathematics technology in the classroom to include the promotion of students' 'higher order thinking skills, developing and maintaining their computational skills, facilitating their algebraic and geometric skills, and showing them the role of mathematics in an interdisciplinary setting.' These require technological resources. From the findings, it was established that non-accessibility of internet connectivity and the maintenance and support of computer labs continued to be significant challenges in the use of digital resources at the five high schools. This also applies to the operational and functional use of the computer labs sponsored by the Khanya project and the Telematics programme entailing interactive afternoon satellite broadcasts of additional lessons. It is a challenge to assess the status of maintenance and support mechanisms because the alternatives are so varied. In the early stages of implementation of technology in schools, the need for maintenance is often overlooked. Volunteers are pressed into service, or teachers with an interest in technology are assigned support roles in addition to their other obligations. Such systems and roles are difficult to sustain. It is a hallmark of the institutionalisation of technology that more formal systems for maintenance and support have been established (National Centre for Education Statistics, 2002).

From the above findings it is recommended that the relevant education department should invest in the employment of Information Technology (IT) staff that provide school level support and maintenance of structures without having to consult outsourced service

providers. They can be available on a full-time basis, whereby this support can be provided without delaying or interrupting the learning and teaching process. Regular training on software and applications can be arranged at school level at regular intervals for teachers and students.

With regard to the internet connectivity issues at these schools, it has been confirmed by officials of the WCED that they are in the process of providing broadband connection to all schools in the Western Cape. It remains to be seen if this will be affected. It is also suggested that more technological training and support workshops be made available, especially to 'older' teachers, so that they can fully utilise the advantages of using technological resources in the classroom.

6.2.5.2.1 The use of computer and mobile applications in the classroom

Teaching and learning methods utilised at schools are often not in tandem with the fast pace of technological advancement. Unlike learning and teaching that is limited to the classroom, new trends on learning such as the use of mobile applications are readily available around the clock. App learning (using mobile phone or computer applications) is not time-bound learning; it is relaxed learning. One of several advantages is that computer and mobile application-based learning allows teachers more time to discuss lesson plans for better interactive classes. It also gives students the chance to work at their own pace, taking extra time in the areas where they need it most (Lynch, 2015). More particularly, students are able to learn academic content in a manner that they are acquainted with.

Alongside the benefits, mobile devices certainly come with their share of complications. Hall, Cohen, Vue and Ganley (2015) infer that the use of technology in the classroom does not automatically equate to better effectiveness and better outcomes. Other challenges might include the negative impact of bring-your-own-device policies which may draw attention to situations where some students are more privileged than others, cases of theft, and then there is the question of student attentiveness and teacher authority within the classroom (Lynch, 2015). However, the use of mobile applications as tools for learning and teaching should be encouraged within South African schools. Although some schools in South Africa have received tablets from various private organisations, there still remains a dearth of technological upgradings of resources sponsored by external and private organisations,

particularly in schools in disadvantaged communities. National and provincial education departments should liaise and form collaborations with private organisations in an effort to fund and donate mobile devices and mobile applications and software to more schools. These devices and applications should include E-readers, educational and subject specific applications, text-response programmes, and the use of various search engines (for the purpose of doing research).

6.2.5.3. Human resources

Some of the current critical challenges faced by teachers in South Africa and many other countries with emerging and developing economies relate to their own lack of mathematical content knowledge, and the skills required to apply what they know in the classroom (Stols et al., 2015). According to Rowland and Ruthven (2011), it is generally agreed that the quality of teaching depends on the knowledge the teacher brings to the classroom.

Teacher status and quality during the democratic era evolved at different levels. In conceptualising the inherited challenges of the apartheid regime, the National Teacher Education Audit (1995) was implemented. This audit revealed that the general teacher education quality was “poor, inefficient and cost-ineffective”. It is for this reason that teacher qualifications in South Africa should be reviewed and adjusted, primarily for those teachers who received their qualification under the apartheid system.

Incorporation of teacher training colleges established during the apartheid era was done without proper planning and foresight about the impact the incorporation would have on producing teachers. Disaggregated teachers received varied quality of teacher training in historical colleges. As a result, post-apartheid South African education experienced a shortage of teachers for certain subjects and rural schools. With the implementation of upgraded qualifications, relevant education authorities did not have an in-depth understanding of the inequalities, and were therefore unable to give proper attention to the design of ‘catch-up programmes’. An added consequence of this is the decline in teacher morale, particularly in subjects such as mathematics (Feza & Diko, 2014).

Often, due to a lack of skilled and qualified teachers at South African schools, teachers are allowed to teach any subject that they do not have expertise in. Whilst the teaching of some

subjects does not require problem solving, amongst other skills, this unfortunately is not the case for mathematics teaching and learning (Savides, 2017). The outcome of such situations results in teachers having a lack of confidence in teaching the subject, and more significantly, not doing any justice to the future of mathematics teaching and learning in the country (The Centre for Development and Enterprise (CDE), 2013). This lack of confidence in teaching mathematics as a subject has been revealed by some of the mathematics student respondents in the study. A teacher's sense of confidence in teaching a subject will possibly have a positive impact on the teaching methods they use. Against this background, it is highly recommended that effective professional development should be on-going, and should include training, mentoring practices, ongoing feedback, and providing follow-up support for teachers (Organisation for Economic Co-operation and Development (OECD), 2009). Teacher morale should be a main focus with the intention of offering attractive incentives and addressing salary matters, and allowing teachers to become experts in their fields through research, writing and publishing and thereby contributing to the profession (Armstrong, 2015).

6.2.6 Primary school preparation for high school mathematics

The “gap between what students should know and what they do know” grows over a period of time. These students, due to the gaps in their learning, will fall further and further behind in their studies until such time that remediation is virtually impossible (Reddy, 2015). Notably, challenges pertaining to this section were identified as having similar recommendations to that of human resources (discussed in the section above). The foundational and basic understanding of mathematical concepts were identified as a challenge, particularly for students in the transition from the primary school (Grade R to 7) to the high school GET phase (Grades 8 and 9) and the FET phase (Grades 10 to 12). Students do not necessarily possess these skills for higher level (abstract) thinking in mathematics when they reach these phases. According to Reddy (2015), one possible explanation for this is that teachers in South Africa present problems of a low cognitive demand and teach what they are competent to teach. Students, therefore, cannot be expected to do well in any international bench-marked tests. In general, students' subject knowledge cannot exceed that of the teacher. Teacher content knowledge and qualifications can be regarded as a contributing factor to the ‘gap’ in students' knowledge and understanding of mathematics, particularly when transitioning from primary

school to high school. Evidently, the suggested recommendation in this section is similar to those identified in the previous section on human resources (6.2.5.3).

6.2.7 Support from the Western Cape Education Department (WCED)

6.2.7.1 Mathematics Curriculum Advisors

6.2.7.1.1 Curriculum Support

From the research conducted in this study, it was identified that there is a shortage of curriculum advisors in the Western Cape Education Department (WCED). It was determined that the lack of Mathematics Curriculum Advisors (MCAs) is due to financial reasons. Information on the roles and responsibilities of the CAs, as stated in ELRC's Policy Handbook for Educators (PHE) (DoE, 2003), considers curriculum delivery to be the "core process" that defines the role of the curriculum advisor. From the responses of the teacher participants in this study, there is a definite need for leadership by curriculum advisors. This includes the creation of an environment that creates and fosters commitment and confidence among colleagues and teachers, while promoting the values of fairness and equity in the workplace. Furthermore, CAs need to provide professional leadership by assisting teachers in identifying, assessing and meeting the needs of students. In this manner, they encourage the application and dissemination of good practices in all areas of work (ELRC, 2003). Considering the invaluable role of MCAs in the support they provide in curriculum delivery, and therefore having a direct impact on the success of the teaching and learning of mathematics as a subject at schools, it is recommended that investments should be made in the training and employment of more MCAs.

6.2.7.1.2 Resources

As a matter of concern, the study revealed inconsistencies in responses between the CAs and participants interviewed at the schools with regard to the allocation of resources to the respective schools. This study could not determine what the true reflection of the matter was. However, this raises concerns about the management of those at the departmental level responsible for resource allocation to these schools, and those at the school level. A continuous review of job specification policies within these different departments at the WCED and at school level is recommended. Management officials at the WCED should establish appropriate monitoring systems for the effective implementations of such job

responsibilities. Accountability should become a priority within these stipulated policies and documents.

6.2.7.1.3 Continuing Professional Development

6.2.7.1.3.1 Teacher training workshops

Although no specific adverse remarks were made regarding the effectiveness of the teacher training workshops initiated by the Western Cape Education Department, as a general observation, workshops and training programmes should result in specific changes in what and how people do certain things. The organisers of these workshops should pay careful attention to the objectives of such workshops and need to have the deliberate inputs of those at grassroots level (teachers and students), especially in the evaluation process to assess the quality of training (Rahman et al., 2011). More importantly, for any teacher training workshop to be effective, assessment should be conducted in terms of its impact and teachers' ability to teach the curriculum and assess students in line with national policy on the education system's role in creating a collaborative society (Harley & Parker, 1999). Very often, evaluation of training is done poorly or not at all. One reason for this is that it is assumed that the training will work. Another reason is fear among the initiators of the training that an objective evaluation might show deficiencies in the training. Planning for the evaluation should coincide with planning for the training programme (Swanepoel & Erasmus, 2000:517).

However, it is crucial for the success and future of teacher training workshops to meet the needs of all stakeholders (teachers and students) in the teaching and learning of mathematics. There needs to be more widespread agreement amongst all stakeholders of any problem that arises, and a willingness to address it at all levels, from the individual teacher who needs to start taking responsibility for his/her own learning; to the subject leaders (HODs) who need to start providing support to teachers at their sites; to the MCAs who need to ensure that they are providing support to teachers; and to the Education Departments who must commit to managing their departments (Maoto, Chigonga & Masha, 2015).

6.2.7.2 Support programmes for mathematics teachers and students

6.2.7.2.1 Communication Strategies

Several of the mathematics student participants at the schools in this study emphasised that they are not fully aware of the existence of mathematics support programmes available to them. This indicates a serious lack of service delivery from the Western Cape Education Department. This shortcoming suggests a review of the Service Delivery Improvement Plan (SDIP) initially implemented in 2015 and more recently in 2018, with the intention of improving communication between the Western Cape Education Department and management at the school level. Systems should be in place where this information is communicated to all students at the schools and parents within the school community, as well as allowing sufficient time for responses. This requires the implementation of effective planning strategies by those who present and undertake such support programmes.

It should be noted that managing communication effectively is a key dimension of leadership. The New Zealand Ministry of Education (2018) reports that effective communication underpins the knowledge, skills and dispositions principals require to have a direct and indirect influence on student outcomes. Taking time to review each school's communications strategy and ideas will be time well spent. Many problems, in and out of schools, can be directly traced to the effectiveness of the school's communications – whether information was communicated or not, what was communicated, how it was communicated, and who communicated it. It is recommended that principals apply a range of formal and informal communication methods on a daily basis. This should be knowingly scheduled through deliberate communication (planned in meetings) or ad hoc (emergency-unplanned); face to face or virtual; written, video or verbal; digital or non-digital; and individual or in a group setting. According to the teacher participants in this study, a similar situation exists regarding the communication and timeous notification of information on the developmental and generic workshops offered to teachers by the Western Cape Education Department.

6.2.7.2.2 Practicality, Application and Attendance

In terms of the effectiveness of workshops, most respondents indicated a clear absence of the evaluation and monitoring of the practical application in the classroom of information obtained in these workshops. It is for this reason that it is important to have follow-up

workshops that focus on the practicality and the validity of such programmes. Furthermore, attendance of such mathematics support programmes should be made compulsory for all identified mathematics teachers and students that are in grave need of the support.

The following criteria are suggested in the selection of mathematics teachers and students:

Teachers: Those teachers who are teaching the subject but have no qualifications or subject specialisation.

An Annual Report of the Department of Education (DoE, 2007:71) states that ". . . the uncertainty with regard to the number of under-qualified and unqualified teachers in the system is a challenge to the system". The role of teachers' pedagogical knowledge and skills in their subject area is acknowledged to be key. Teachers' craft knowledge - that is, knowledge and beliefs regarding pedagogy, students, subject matter and curriculum - is related to teacher effectiveness (Van Driel, Verloop & de Vos, 1998; Darling-Hammond, 2000; Hill et al., 2005). Moreover, there is overriding evidence that teacher quality in terms of teacher preparation and qualification strongly influence students' levels of achievement (Darling-Hammond, 2000; Goldhaber & Brewer, 2000; Darling-Hammond, Berry & Thoreson, 2001).

Furthermore, the Department of Basic Education (2015) introduced the 1+4 pre and post test system for teachers. This scheme identified and reported that teachers lacking in both mathematics content knowledge and teaching methods most certainly have a negative impact on the quality of mathematics education, and therefore student performance in the subject.

Students: Low performing students in mathematics identified from Grade 8 onwards, persistently underperforming.

According to Reddy, Van der Berg, Janse van Rensburg and Taylor (2012) there is a strong correlation between Grade 8 mathematics performance and matric mathematics achievement. Mathematics performance in the earlier years predicts later mathematics performance. To raise exit level outcomes, mathematics scores need to be raised by Grade 8 or earlier. In support, the TIMSS 2015 results reflected this concern when viewing the Grade 9 results. Only 1.3% of South African mathematics students scored at the advanced level of

achievement, compared to the global performance indicator of 6% for all students in the study at this level (Ngoepe, 2016).

Table 6.1 provides an overview of recent (2016 and 2017) National Senior Certificate (NSC) mathematics results, with corresponding numbers guaranteed admittance to engineering and computer science university study.

Table 6.1: NCS mathematics results in 2016 and 2017

Subject	Number wrote 2016	Number passed 2016	Number wrote 2017	Number passed 2017	Change (passed)
Mathematics	265 810	135 958	245 103	127 197	-8 761
Guaranteed Engineering entry	Number above requirements 2016	% of total 2016	Number above requirements 2017	% of total 2017	Change
Mathematics (80%)	7 974	3.0%	6 726	2.7%	-1 248
Guaranteed Computer Science entry	Number above requirements 2016	% of total 2016	Number above requirements 2017	% of total 2017	Change
Mathematics (70%)	18 075	6.8%	16 565	6.8%	-1 510

Source: 2017 School Subject Report, 2016 Diagnostic Report, UCT. Numbers are approximates based on supplied data.

Some of the mathematics student participants in this study revealed that the existing mathematics support programmes, such as the Telematics mathematics support programme offered at certain schools, benefit only a small number of students who reside in the area of the schools, and exclude a large number of students who do not reside in the area. This places huge limitations on students that are particularly in need of such mathematics support programmes. When implementing such support programmes, it is recommended that these mentioned factors be considered. The Development Bank of Southern Africa (DBSA) (2009) socioeconomic and spatial inequalities in the South African development landscape report calls for a paradigm shift in the way development is carried out. The DBSA further asserts that it is crucial that a coalition of the community and all development practitioners is forged for

the development processes to shift from planning for people to planning with people (Khosa, 2013).

Furthermore, it appears from the research findings in this study that a significant number of participants do not utilise these support opportunities. It is recommended that the attendance of mathematics support programmes such as the above-mentioned generic workshops for teachers as well as the tutoring programmes offered by the University of Cape Town, the University of the Western Cape and Stellenbosch University for mathematics students should be made compulsory for all identified students and teachers who are in grave need of the support. From the responses of the participants, it was deduced that many struggling students in mathematics often do not attend holiday support programmes because attendance is not compulsory. In contrast, the student participants in this study who do attend these holiday programmes indicated that the tutoring service offered by tutors from the respective universities is indeed very helpful and beneficial to their understanding of 'difficult' content in mathematics.

6.3 CONCLUSION

It is inevitable that shortcomings will exist in any mathematics support programme. In an attempt to improve any programme for that matter, it is deemed necessary to do continuous research. This is done through selecting active revision and evaluation strategies of such programmes with the aim of continuous improvements. In this study, several such mathematics support opportunities were identified by teacher and student participants at five high schools in previously disadvantaged areas in Cape Town, including those that the mathematics students and teachers were not aware of, but were available. The following section provides a specific summary of the elements of the most appropriate mathematics support opportunities to correlate with the purpose of this study, and to answer the research question of: *Identifying the most appropriate mathematics support opportunities available for mathematics students and teachers at high schools in the Cape Flats area in Cape Town.*

The Strategy for Mathematics and Physical Sciences for Grades 8 to 12 (2012-2015) mathematics support programme can be viewed as an archetype of the most appropriate mathematics support programme to fulfil the needs and address several areas of challenges

experienced by all stakeholders in mathematics education at the five high schools. This strategy is an archetype for the following reasons:

It involves various partnerships with mathematics experts from outside the government through strong systems of accountability and support. In addition to this, they provide physical resources for mathematics teachers and students, such as calculators, question papers and memoranda of previous Grade 12 mathematics question papers. The use of technology is motivated by ICT – in the form of software and hardware, digital resources, broadcasting Telematics lessons to schools and integrating interactive mathematics teaching and learning. The student support offered, in the form of Saturday and holiday tutoring, and the various competitions such as the Mathematics Olympiad programmes are a committed effort on behalf of all those involved.

However, the following attributes are present in other support programmes, mentioned in this study. For the purpose of answering the research questions, these existing features can be incorporated into this strategy to enrich its appropriateness to the needs of the mathematics students and teachers at the five high schools where this study was conducted. An example is the courses designed and offered by AIMSSEC for underqualified mathematics teachers. An alternative to the workshops offered by the WCED, although valuable, can be its transformation into qualification courses for underqualified mathematics teachers, such as the one offered by AIMSSEC. In addition, this course should require mathematics teachers to continuously upgrade their qualifications, as a means of acquiring subject specialisation. The content and outcomes of such mathematics courses should prioritise curriculum delivery, the structural aspects of the prescribed curriculum, and teaching methodology that is based on continuous research of the learning and teaching experience of mathematics in the actual classroom. These recommended courses should emphasise the use of mentors, as often mathematics teachers have obtained knowledge, but experience difficulty in the application thereof. It should be offered to those mathematics teachers identified at schools such as those in this study. In addition, it is highly recommended that these courses be made compulsory to those teaching mathematics at all grades at schools. Ideally such courses should be viewed as an investment into the economic future of our country, South Africa. It is for this reason that such courses should be fully funded and private organisations should be encouraged to invest.

Most of the available mathematics support programmes mentioned in this study focus on providing mathematics support to students who are at present performing well above the average in mathematics, and it therefore perpetuates an existing challenge. The Strategy for Mathematics and Physical Sciences for Grades 8 to 12 should aim at including more low-performing schools in the available mathematics support programmes. Low performing schools in mathematics should receive the closest attention since the majority of the mathematics support programmes that are currently available, such as the Dinaledi schools initiative (which forms part of the strategy), the SMILES initiative and the Zenex foundation, do not provide access to underperforming mathematics students in previously disadvantaged areas. These mathematics support programmes need to be closely examined and investigated in terms of their objectives, and reviewed and adjusted to accommodate the struggling mathematics students at high schools in the Cape Flats area in Western Cape.

Characteristically the most appropriate mathematics support programme needs to have effective communication structures in place where all information on workshops and mathematics support programmes ought to be communicated directly and timeously to the relevant stakeholders within the schools. The Telematics interactive mathematics support programme, already part of the strategy and although valuable, needs to be expanded to more schools in areas where students underperform in mathematics, through forming productive networks with private organisations in a bid for financial support to enhance school and community development.

As part of the strategy, the Western Cape Education Department needs to make internet connectivity a priority and therefore accessible to all the schools in this study, and all other schools in the Cape Flats for that matter. Irrespective of the computer programmes installed or software sponsored, none will be functional without internet connectivity, and especially the absence of an operative maintenance support infrastructure. All support programmes should motivate the use of technology within classrooms as a more advanced means of teaching and learning mathematics. The most appropriate mathematics support programme should take into consideration the ratio of departmental officials per district, as in the case with Mathematics curriculum advisors (MCAs), which needs to be statistically realistic in terms of the execution of the goal to deploy effective monitoring and evaluation, a crucial part of support.

Lastly, the Strategy for Mathematics and Physical Sciences for Grades 8 to 12 should design compulsory parent workshops in collaboration with private organisations, with the intention of educating parents on levels of parental involvement, which includes issues of career choices, information on available mathematics support programmes and establishing teacher-parent relationships to the benefit of the student.

In essence, all human development should take into consideration the interaction of processes, person, and context, as indicated by Bronfenbrenner's ecological systems theory. This integrated manner of approaching any challenges in mathematics education has proven to be effective in involving all stakeholders, by being accountable and responsible partakers in the future of mathematics teaching and learning in the Western Cape. It is of a hopeful mind that the above recommendations be considered as a prototype for future research into the appropriateness of mathematics support programmes for mathematics students and teachers in previously disadvantaged areas.

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APPENDIX A: ETHICAL APPROVAL FROM WCED



Directorate: Research

Audrey.wynngaard@westerncape.gov.za tel: +27 021 467 9272 Fax: 0865902282

Town, 8000 wced.wcape.gov.za

REFERENCE: 20151015-4250 **ENQUIRIES:** Dr A T Wyngaard

Private Bag x9114, Cape

Ms Fadilah Allie
2 Twickenham Way
Edgemead
7441

Dear Ms Fadilah Allie

RESEARCH PROPOSAL: SUPPORT FOR MATHEMATICS TEACHERS AND STUDENTS IN PREVIOUSLY DISADVANTAGED CAPE TOWN HIGH SCHOOLS

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and students are under no obligation to assist you in your investigation.
2. Principals, educators, students and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **18 January 2016 till 31 March 2016**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

**The Director: Research Services
Western Cape Education
Department
Private Bag X9114
CAPE TOWN
8000**

We wish you success in your research.

Kind regards.

Signed: Dr Audrey T Wyngaard

Directorate: Research

DATE: 16 October 2015

APPENDIX B: ETHICAL CLEARANCE FROM CPUT

***For office use only	
Date submitted	1 October 2015
Meeting date	n/a
Approval	P/Y/N
Ethical Clearance number	EFEC 2-10/2015



FACULTY OF EDUCATION

RESEARCH ETHICS APPLICATION FORM

This form is to be completed by students, staff members and other researchers intending to undertake research in the Faculty. It is to be completed for any piece of research the aim of which is to make an original contribution to the public body of knowledge.

Please note:

- Complete the form in MS Word – no handwritten forms will be accepted.
- All attachments are to be included in this document – your email submission should include only **one** MS Word attachment.
- Your surname must appear at the beginning of the file name, e.g. SMITH Ethics application

1 Applicant and project details

Name(s) of applicant(s):	FADILAH ALLIE
Project/study Title:	Support for mathematics teachers and students in previously disadvantaged Cape Town high schools
Is this a staff research project, i.e. not for degree purposes?	NO
If for degree purposes:	YES
Funding sources:	URF

2 Abstract of study

Globally, competence in mathematics is generally recognised as a critical skill directly related to occupational and educational choices, and thus having an impact on the economic development of a country (Tsafe, 2014). While the same view about mathematics is held in South Africa, sadly, in this country the overwhelming majority of school leavers appear to have limited educational and career support in occupational fields such as medicine, engineering, information technology and scientific research because of the poor performance in mathematics and science at Grade 12 level. Furthermore, underachievement in mathematics is particularly recognised as a major problem in schools serving previously disadvantaged communities in South Africa (Mkhabela, 2004).

According to Williams (2014), South Africa has the worst science and mathematics teaching in the world. He attributes this situation to inadequate apartheid-era teacher training and ineffective post-apartheid in-service training. According to Education For All (EFA, 2005), one of the underlying reasons for the challenges in mathematics teaching is the shortage of qualified mathematics teachers. Thus, although 85% of mathematics teachers in South Africa are professionally qualified, only 50% specialised in mathematics (EFA, 2005)..

Several studies have shown a correlation between school environment and students' achievement at school (Tsanwani, 2009: 1819). Murray has shown, for example, that schools in the Western and Northern Cape provinces that are located in well-endowed white communities have high pass rates in Grade twelve examinations, whereas those in Limpopo Province with its black majority rank low in performance (Murray, 1997). Similarly, Attwood (2001) found that Grade eight students in schools situated in economically depressed areas of the Cape Flats have a lower mathematics achievement than those from schools located in areas with high socio-economic status. In part this has to do with the availability of resources. Reddy et al (2015) have found that South African schools are negatively affected in terms of mathematics performance due to a lack of physical infrastructure such as computers as well as teaching materials.

Given these challenges, it is reasonable to conclude that there is a need for support programmes for both mathematic teachers and students in South African schools, and in particular those in previously disadvantaged communities (Makgato & Mji, 2006: 254-5). These support programmes might help to improve students' performance and teachers' productivity in mathematics. For instance, Siyepu (2013: 10) argues that teachers' competencies may be improved by means of in-service courses. This view is confirmed by Makgato and Mji (2006: 254) who state that in 2001, the Department of Education estimated that 8,000 mathematics teachers needed in-service training. In the same year, the Department introduced the Dinaledi Programme to provide support in the form of physical resources and equipping teachers with the necessary pedagogical and content skills to improve the science and mathematical results within a few selected schools.

Several studies have been conducted of the various support programmes that have been introduced in South Africa (Reddy, Lebani, & Davidson, 2003; Reddy, Berkowitz, & Mji, 2005; Coetzee, 2008; Ndlovu, 2011; Zenex Foundation, 2012; Centre for Development and Enterprise, 2013; Dime Brief, nd). However, the bulk of these studies focus on a single programme, such as supplementary tuition, or programmes that were restricted to a select group of schools, such as the Dinaledi and SMILE support. No comprehensive study has been conducted of access to, or utilisation of support programmes for mathematics teachers and students at disadvantaged schools. In this regard, the study will explore factors underlying access to, and utilisation of support programmes for mathematics teachers and students, as well as teachers' and students' perceptions of the strengths and limitations of particular programmes. Included here will be a study of teachers' and students' perceptions of parental support for mathematics learning at disadvantaged schools. Given the wide range of efforts to improve mathematics teaching and learning, there is justification for study of access to, and utilisation of support programmes for mathematics education in disadvantaged schools. This study will hopefully facilitate the quest to improve achievement in mathematics in disadvantaged schools and establish what schools, teachers, parents and students can derive from mathematics teaching and learning support programmes.

As shown above, the picture of the support provided for mathematics teachers is of fragmented efforts provided by distinct entities. These efforts fail to provide a comprehensive and systematic analysis of the support given to the teachers and students. Hence a need for such a study that investigates interactions and collaborations by various stakeholders (teachers, peers, students, parents, teacher support systems and school governing bodies).

3 Ethical considerations specific to the intended study/project

Provide explicit and concise answers to the following questions:

- 3.1 Sampling: How will you recruit participants? Is there any possibility that participants might feel coerced to take part and if so how can you manage this issue?

Participants will be recruited from five high schools located in the Cape Flats area using the purposive sampling technique, which requires identifying the participants with the relevant knowledge and expertise, to select four mathematics teachers from each of the five school in each phase; five officials from the Western Cape Department of Education and 100 students from the mathematics Grade 12 classes at the five schools.

No coercion will be involved in the participants' participation in the study.

- 3.2 How will participants be made aware of what is involved in the research [prior to, during and after data collection]?

The participants will be provided with an information form setting out the objectives of the research and their required role in it.

- 3.3 How will you ensure that participants really do understand their rights?

All the participants' rights to participate or not to participate in this project will be explained to them in the information and consent forms and that they have a right to withdraw their participation at any time.

- 3.4 How will you collect data?

Data will be collected in interviews, focus groups and a survey.

Attach your data collection instrument(s) to the end of this document.

- 3.5 Is there a risk of harm to participants, to the participants' community, to the researcher/s, to the research community or to the University? If so how will these risks be managed?

I am unaware of any possible harm to any of the above mentioned participants.

- 3.6 What plans do you have for managing the confidentiality and anonymity of participants in this study?

A pseudonym will be used for every participant that will only be known to the researcher. That name will apply on all documentation. The data will be stored in a safe place accessible only to the researcher.

- 3.7 Are there any potential conflicts of interest for you in undertaking this study?

I am not aware of any possible conflicts of interest.

3.8 How will the findings be used on completion of the study?

It will be submitted to the department of education to help them with future policy reform and implementation. Also to the participants of this study, mathematics teachers in the Western Cape and researchers who gain access to the thesis.

3.9 Does this work raise any other ethical issues and if so, how will you manage these?

No.

3.10 What training or experience do you bring to the project that will enable you to recognize and manage the potential ethical issues mentioned above?

I have prior experience in conducting interviews with similar participants.

4 Research Ethics Checklist

Ethical considerations:	Yes	No
4.1 Does the study involve participants who are unable to give informed consent? Examples include children, people with learning disabilities, or your own students. Animals?		x
4.2 Will the study require the co-operation of a gatekeeper for initial access to the groups or individuals to be recruited? Examples include students at school, members of self-help groups, residents of nursing homes — anyone who is under the legal care of another.	x	
4.3 Will it be necessary for participants to participate in the study without their knowledge and consent at the time — for example, covert observation of people in non-public places?		x
4.4 Will the study with the research subject involve discussion of sensitive topics? Examples would include questions on sexual activity or drug use.		x
4.5 Will the study involve invasive, intrusive, or potentially harmful procedures of any kind (e.g. drugs, placebos or other substances to be administered to the study participants)?		x
4.6 Will the study involve prolonged or repetitive testing on sentient subjects?		x
4.7 Will financial inducements (other than reasonable expenses and compensation for time) be offered to participants?		x
4.8 Does your research involve environmental studies which could be contentious or use materials or processes that could damage the environment? Particularly the outcome of your research?		x


5 Attachment checklist

Please Tick:

The following documents have to be included at the end of this document:

Attachment	
5.1 Consent form	√
Data collection instrument(s)	√
5.2 Other relevant documentation (Please specify)	√

Signatures:

Researcher/Applicant:		Supervisor or Senior investigator (if applicable):	
Date:	30.09.2015	Date:	

Please note that in signing this form, supervisors are indicating that they are satisfied that the ethical issues raised by this work have been adequately identified and that the proposal includes appropriate plans for their effective management.

Comments by Education Faculty Ethics Committee:

The Education Faculty Ethics Committee grants unconditional ethical clearance to the study which is valid for 4 years from the date of issue.

Approved: X

Referred back:

**Approved subject
to adaptations:**



Chairperson:

Date: 06/10/2015

Approval Certificate/Reference: EFEC 2-10/2015

APPENDIX C: INFORMATION SHEET 1

Who I am

Hello, I am Fadilah Allie. I am a student at the Cape Peninsula University of Technology (CPUT) working on my Doctorate in Education. The CPUT is a tertiary education institution based in central Cape Town. The University provides quality education to students in a variety of fields.

What I am doing

I am currently conducting research on the challenges in, and support given to Mathematics teachers and students in the senior phase of education. For this study, I am conducting interviews with heads of department, teachers and Grade 12 students at certain schools, as well as officials from the Department of Education, to identify the particular challenges faced in Mathematics learning and teaching, the types of support given by the Education Department and external institutions, and the strengths and limitations of this support. I will be asking you questions about these three areas and will use the information gathered from the discussion, together with other research material, to write a thesis for my Doctoral Degree in Education and for further publications later on.

How I obtained your name

I obtained your name from the Western Cape Department of Basic Education and/or your school.

Your participation

Your position has been identified as important in relation to our study and I am inviting you to share your views with us on a free and voluntary basis. If you do agree to participate in the study, I will meet with you individually for approximately 60 minutes of your time when I will put some questions to you.

Please understand that **your participation is voluntary** and you are not being forced to take part in this study. The choice of whether to participate or not is yours alone. If you choose not to take part, you will not be affected in any way whatsoever. If you agree to participate, you may withdraw your consent to participate at any time before or during the study without penalty or negative consequence.

Confidentiality

With your permission, the interview will be recorded. If you agree that your answers may be recorded, it will be linked to a fictitious code number. No one will be able to link you to the answers you give. Your name and the name of your school will also not be attached to the transcript. The information will be stored electronically in a secure environment and used for research purposes now or at a later date. The digital audio tapes will also be stored on a secure personal computer for a period of one year after the completion of the project before it will be deleted.

Risks/discomforts

At the present time, we do not see any risks in your participation.

Benefits

There are no immediate benefits to you from participating in this study, and there will be no payment involved for your participation in the interview.

Contacts

If you have further questions about this project, about the results of this study, or if you have a research-related problem, you may contact me, Fadilah Allie, on 0734407248.

Alternatively, you may contact my supervisor, Dr. Lungi Sosibo, on 0710701266, e-mail sosibol@cput.ac.za.

If you are willing to participate in this study, please sign the attached consent form. If you have any questions at any time, please feel free to contact me on the telephone number provided.

APPENDIX D: CONSENT FORM

I hereby agree to participate in the research on the challenges faced in Mathematics learning and teaching, the types of support given by the Education Department and external institutions, and the strengths and limitations of this support. I have read the Information Sheet and have had details of the study explained to me. My questions have been answered to my satisfaction and I understand that I may ask further questions at any time.

I understand I have the right to withdraw from the study at any time and to decline to answer any particular questions. I also understand that if I decide to stop participating or refuse to answer any particular question this decision will not in any way affect me negatively.

I agree to provide information to the researcher[s] on the understanding that my name will not be used without my permission. *The information will only be used for this research and for publications that might arise from this research project.*

I agree/do not agree to the interview being recorded [audio/visual].

I understand that I have the right to ask for the recording equipment to be turned off at any time during the interview.

I confirm I am over 16 years of age.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signed.....

Name.....

Date.....

Thank you for your willingness to participate in this study

APPENDIX E: INTERVIEW SCHEDULE – HEADS OF DEPARTMENT AND MATHEMATICS TEACHERS

The following pages contain questions that will be asked during the interviews with the Mathematics heads of department and teachers.

PERSONAL BACKGROUND/INFORMATION

1. Could you please give a brief biographical background about your education and experience?
2. How long have you been teaching at this school?
3. How long have you been in this position at this school? (HoD/Teacher)
4. What factors accounted for your appointment as a Mathematics HoD/teacher?
5. Did you have specific training in Mathematics education in your teaching education course?

TRAINING AND SUPPORT FOR MATHEMATICS TEACHERS

6. As a Mathematics teacher, are there any specific challenges you personally face in Mathematics teaching?
7. Have you undergone any course(s) on professional development in Mathematics teaching methods since you were appointed as a Mathematics teacher?
8. If yes, was the course(s) of any help in your teaching of mathematics?
9. Are you aware of any Department of Education policies regarding support for Mathematics teachers? If yes, what are they?
10. Has any additional support been given to you by the Department of Education to assist you with teaching Mathematics? If yes, what are they?
11. If yes, was this support useful? Please explain.
12. Are there any other institutions/organisations that have played a role in providing you with support for Mathematics teaching?
13. If yes, was the support provided useful?
14. Are the mathematics teachers at this school adequately qualified and capable to provide quality mathematics education? Please explain.
15. What type of training/support do you think is required for Mathematics teachers at this school?

CHALLENGES OF MATHEMATICS STUDENTS

16. How do the Mathematics students at this school perform in comparison to students at other schools in the area? What reasons account for their performance?
17. Do you think there is room for improvement in performance in Mathematics at the school?
18. Do you think that the students that come to this school are adequately prepared for Mathematics learning at the primary schools from which they come?
19. What is the students' socio-economic background at this school and how does it impact on their performance in Mathematics?
20. Do you think that the parents of the students at this school support their children's mathematics education? Please explain?
21. Are there adequate Mathematics resources at the school? Please explain?
22. What other challenges do you see among the Mathematics students at this school?

SUPPORT TO MATHEMATICS STUDENTS

23. Are you aware of any Department of Education policies regarding support for Mathematics students?
24. What special measures or support is given to Mathematics students at this school by the Department of Education?
25. If any, do these measures or support have any impact on performance in Mathematics?
26. Is there any way these measures or support can be improved?
27. Are there any other institutions/organisations that have played a role in providing support to Mathematics students at this school?
28. If yes, was the support provided useful?
29. What type of training/support do you think is required for Mathematics students at this school?

APPENDIX F: INTERVIEW SCHEDULE – OFFICIALS OF THE WESTERN CAPE EDUCATION DEPARTMENT AND MATHEMATICS TEACHERS

The following pages contain questions that will be asked during the interviews with the Officials of the Department of Basic Education responsible for support for Mathematics teaching and learning at schools in the Cape Flats.

PERSONAL BACKGROUND/INFORMATION

1. Could you please give a brief biographical background about your education and experience?
2. How long have you been in your current position?
3. What factors accounted for your appointment to this position?
4. Could you please give a description of your key responsibilities?

CHALLENGES OF MATHEMATICS EDUCATION ON THE CAPE FLATS

5. How do the Mathematics students in the schools in the Cape Flats perform in comparison to students at other schools in the Cape Town area?
6. Are there specific schools that perform well in Mathematics and others that are poor performers?
7. Why do you think this is so?
8. In what respects do you think the challenges that schools face in Mathematics education at the schools in the Cape Flats relate to problems with the type of students at these schools?
9. In what respects do you think the challenges relate to problems with the Mathematics teachers at these schools?
10. In what respects do you think the challenges relate to the conditions or circumstances at these schools, for instance, shortages of mathematics resources, classrooms, etc.?
11. What other challenges do you see in Mathematics education at these schools?

TRAINING AND SUPPORT FOR MATHEMATICS TEACHERS

12. Are there any Department of Education policies regarding support for Mathematics teachers?

13. What additional training/support has been given to Mathematics teachers by the Department of Education to assist them with teaching Mathematics?
14. If yes, was this training/support useful? Please explain.
15. Are you aware of any other institutions/organisations that have played a role in providing teachers with support for Mathematics teaching?
16. If yes, was the support provided useful?
17. What type of training/support do you think is required for Mathematics teachers at the schools in the Cape Flats?

SUPPORT TO MATHEMATICS STUDENTS

18. Are there any Department of Education policies regarding support for Mathematics students?
19. What special measures or support are given to Mathematics students at schools in the Cape Flats by the Department of Education?
20. If any, do these measures or support have any impact on performance in Mathematics?
21. Is there any way these measures or support can be improved?
22. Are you aware of any other institutions/organisations that have played a role in providing support to Mathematics students at this school?
23. If yes, was the support provided useful?
24. What type of training/support do you think is required for Mathematics students at the schools in the Cape Flats?

APPENDIX G: INTERVIEW SCHEDULE – FOCUS GROUPS WITH GRADE 12 MATHEMATICS STUDENTS

The following pages contain questions that will be asked during the interviews with the Grade 12 Mathematics students.

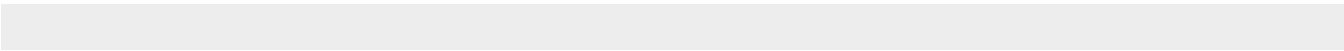
1. Could we discuss why you decided to take up Mathematics at the FET level?
2. Do you think that this school provides a good education in Mathematics?
3. How do you think this school performs in Mathematics in relation to other schools that provide Mathematics education in the area?
4. Could we briefly discuss your experience of Mathematics education at this school?
5. As a learner at this school, are there challenges you face in Mathematics?
6. Are there sufficient resources for Mathematics education at this school? Please explain?
7. When you were doing Mathematics at the GET level, did you participate in any additional activities outside of your normal classes to assist you with Mathematics? If yes, what were they?
8. If yes, was the support provided useful? Please explain?
9. Do you know if support was provided by the Department of Education or by some other institution?
10. Are you currently participating in any additional activity outside of your normal classes to assist you with Mathematics? If yes, what activity is it?
11. If yes, what were the main reasons why you sought this additional assistance?
12. Is this support useful?
13. Do you know if these activities are provided by the Department of Education or by some other institution?
14. What type of other support do you think would help improve your performance in Mathematics at this school?
15. In what ways do your parents support your mathematics education?
16. Do you think this support is enough?
17. What can you say about your home situation that affects your mathematics learning?

APPENDIX H: SURVEY QUESTIONNAIRE –MATHEMATICS STUDENTS

The following pages contain questions for a survey that will be administered after the interviews with the Grade 12 Mathematics students.

In this exercise I am going to ask you to respond to some survey questions. Please select the number below that best represents how you feel about your parents' approach to certain things about Mathematics education.

	Strongly Disagree	Strongly Agree	Agree	Undecided	Disagree
1. My parents encourage me to do my best at school.	1	2	3	4	5
2. My parents allow me to decide on my own what subjects to choose at school.	1	2	3	4	5
3. My parents think that obtaining a Bachelors' Pass is important.	1	2	3	4	5
4. My parents stress the importance of mathematics compared to other subjects.	1	2	3	4	5
5. My parents think that it is more important to be happy than worry about studies.	1	2	3	4	5
6. My parents don't pressure me about my school work.	1	2	3	4	5
7. My parents think it is important to have extra Mathematics lessons.	1	2	3	4	5
8. My parents monitor the time I spend watching television on school days.	1	2	3	4	5
9. My parents constantly check my homework and test results.	1	2	3	4	5
10. My parents expect me to do well at school.	1	2	3	4	5



Synopsis of participants with emergent themes for each school -SCHOOL A

Challenges in mathematics (teachers & students)		Type of mathematics support	Mathematics support programmes participants have access to and utilise
<u>Teachers</u> Resources:		<u>Teachers</u> Mathematics Curriculum Advisors (MCA) <i>(in temporary capacity)</i>	<u>Mathematics Grade 12 students</u>
Lack	Access		No mathematics support programmes they know of at the school
<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Computers (not in a working condition) ▪ Internet access ▪ Maths programmes <p><u>Human</u></p> <ul style="list-style-type: none"> ▪ Qualified, experienced, mathematics teachers ▪ Lack of Mathematics Curriculum Advisor on a permanent basis. 	<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ White boards ▪ Mathematics ▪ Worksheets ▪ Mathematics textbooks ▪ Laptops 	<p>Ensuring mathematics curriculum is implemented through monitoring, evaluation & professional development</p> <p>Finds ways of how to improve mathematics performance</p> <p><u>Monitoring</u> On sight support (daily visits to schools, observing classroom practices with the intention of improving mathematics performance)</p> <p><u>Generic workshops</u> Providing teachers with various methods in teaching mathematics</p> <p><u>Resources</u> Provide the school with data projectors, textbooks, extra mathematics learning material and past exam papers</p> <p><i>Other</i> Provide assistance on how to deal with underperforming mathematics students</p>	<p>Master Maths- Computer installed mathematics software & offered in a private capacity as a mathematics tutoring programme</p> <p>UWC- Holiday tutoring programmes-for mathematics students</p> <p>Study Buddies- Multisensory (text, voice & video operated) computer/phone/I-pad learning software</p> <p>Strengths:</p> <p>Master Maths: School capacity- provides module notes and mathematics worksheets</p> <p>Master Maths: Covers the Mathematics curriculum -CAPS</p> <p>Tuition: Private capacity- one on one tutoring services, including the school capacity advantages</p> <p>UWC: The service is free. Provides mathematics support to students that are struggling in maths.</p>
<p style="text-align: right;"><u>Other</u></p> <ul style="list-style-type: none"> ▪ CAPS Curriculum- too much content to cover in a limited timeframe ▪ Mathematics textbooks outdated 			
	<u>Students</u>	<u>Students</u>	

Resources:		Parental support Some parents pay for private tuition	Covers content in the Mathematics curriculum-CAPS
Lack	Access	Encourage mathematics students to seek assistance with mathematics content they are struggling with	Study Buddies: Step-by-step instructions for students in all school Grade s. Offered in English & Afrikaans Approved by Department of Education Follows the mathematics curriculum-CAPS
<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Mathematics textbooks ▪ Technological resources ▪ IT support ▪ Internet access ▪ Use of mobile application & the use of search engines (e.g. Google) prohibited on personal device in school time. <p><u>Human</u> None</p> <p><u>Other</u> Mathematics Curriculum (CAPS)- structured in a way that it provides limited time to work through syllabus</p> <p>Projectors not in working condition.</p> <p>Teachers lack & use of technology as a tool for teaching.</p>	<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Mathematics textbooks ▪ Mathematics videos ▪ Projectors 	<p>Buy mathematics support computer programmes- Maths Magix</p> <p><u>Colleagues, Mathematics HOD & School Based Support team</u></p> <p>The mathematics HOD provides mathematics worksheets/copied material</p> <p>The mathematics HOD checks up on mathematics teachers</p> <p>The mathematics HOD listens to the mathematics challenges mathematics teachers experience in the teaching of mathematics</p> <p>The mathematics HOD provides mentors for new mathematics teachers</p>	<p>Limitations:</p> <p>Master Maths: Interrupted/No internet connectivity at school</p> <p>Master Maths: No computer lab support structures in place</p> <p>Tuition: Requires private fees/funding</p> <p>Tuition: Tutors teaching methods can be too advanced for struggling students. Different teaching methods can be confusing to the student.</p> <p>Study Buddies: Requires private fees/funding</p> <p><u>Mathematics FET teachers</u></p> <p><u>Numerous Workshops</u></p> <p>Initiated by the Education Department</p> <p>Mathematics content training workshops: Presented by the Department of Basic</p>

			<p>Education (DBE) – offered to Grade 8 & 9 mathematics teachers.</p> <p>Strengths: Mathematics workshops for teachers provide them with valuable information on mathematics content.</p> <p>Mathematics content training workshops provides mathematics teachers in the GET level with continuous support in teacher development and curriculum coverage.</p> <p>Limitations: The school principal informs them too late about the workshop, thus providing them with limited time to respond to such invitations.</p>
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Synopsis of participants with emergent themes for each school -SCHOOL B

Challenges in mathematics (students & teachers)		Type of mathematics support	Mathematics support programmes participants have access to and utilise
<u>Teachers</u> Resources:		Teachers <u>Mathematics Curriculum Advisors (MCA)</u>	Mathematics Grade 12 students
Lack	Access	<i>Workshops</i> Targeted for underperforming schools-assist mathematics teachers on how to deal with underperforming mathematics students	No mathematics support programmes that they know of at the school
<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Scientific calculators ▪ Mathematical sets ▪ Internet access ▪ IT support <p><u>Human</u></p> <ul style="list-style-type: none"> ▪ none <p><u>Other</u></p> <p>Mathematics students at the FET level lack foundation skills of mathematics- suggesting a challenge in mathematics in lower levels of schooling</p> <p>Mathematics Curriculum (CAPS)- structured in a way that it provides limited time to work through syllabus</p> <p>Constant rotation of teachers for mathematics teaching</p>	<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Projectors ▪ whiteboards 	<p><i>Resources</i></p> <p>Offer smartphones, data projectors, laptop to underprivileged, schools that underperforms in mathematics</p> <p><i>Other</i></p> <p>Gives mathematics teachers worked out/planned mathematics syllabus and past exam question papers</p> <p><u>Students</u></p> <p><u>Parental support</u></p> <p>Some parents pay for private tuition Provide mathematics students with guidance in finding mathematics support</p> <p><u>Colleagues, Mathematics HOD & School Based Support team</u></p>	<p>Telematics (Vodacom): Attend interactive online maths support programme at a high school in the area –initiated by the Education Department</p> <p>Strengths:</p> <p>Telematics (Vodacom): The presenters explain core concepts and address problem areas in which students had experienced difficulty in previous examinations. All the broadcast is available on DVD or as part of the online video library, which is a powerful tool the teachers can use for exam revision. A major factor in the success of the project is the dynamic interaction that can take place between the presenters, working from the broadcast studio at Stellenbosch University, and the students watching via satellite or live Internet streaming all over South Africa. The students can ask questions via an interactive web page</p> <p>Limitations:</p> <p>Telematics (Vodacom): No Internet access/broadband connectivity</p>
<u>Students</u> Resources:			

Lack	Access	Mathematics teachers share ideas and printed material with one another	Need to be expanded to more schools/areas with struggling mathematics students.
<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Textbooks ▪ Projectors ▪ No internet access ▪ Computers- in working condition ▪ Use of mobile application & the use of search engines (e.g. Google) prohibited on personal device in school time. <p><u>Human</u></p> <p>Teacher content knowledge of mathematics are highly questionable (possible shortage of mathematics teachers)</p> <p><u>Other</u></p> <p>Lack of effective teaching methods</p> <p>Mathematics Curriculum (CAPS)- too pact limited time to work through syllabus</p> <p>Mathematics teachers have strict control over limited mathematics resources.</p> <p>Limited mathematics textbooks are outdated-</p>	<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Whiteboard ▪ Laptops 	<p>Mathematics HOD too busy to assist, but do however provide mathematics mentors for new mathematics teachers at the school</p>	<p><u>Mathematics FET teachers</u></p> <p><i>Workshops</i> Offered by the Education Department</p> <p><i>Reflection and Review meetings</i></p> <p>Mathematics teachers from various high schools attend this meeting during the course of the academic year and discuss and share new & interesting ways to implement the mathematics curriculum.</p> <p>Resources</p> <p>Strengths:</p> <p>The workshops offered by the Education Department- encourages mathematics teachers to share information on mathematics content, in particular how to structure assessments and how to transfer information properly.</p> <p>Trains mathematic teachers how to conduct proper investigative mathematics task (assignments) for mathematics students.</p> <p>Limitations:</p>

<p>does not correlate within mathematics content explained in class.</p> <p>Teachers lack & use of technology as a tool for teaching.</p>			<p>Reflection and review meetings not very useful, no concrete ideas that will assist underperforming mathematics students</p>
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Synopsis of participants with emergent themes for each school -SCHOOL C

Challenges in mathematics (students & teachers)		Type of mathematics support	Mathematics support programmes participants have access to and utilise
Teachers Resources:		<u>Teachers</u>	Mathematics Grade 12 students
Lack	Access	<u>Mathematics Curriculum Advisors (MCA)</u> No support from MCA	No mathematics support programmes that they know of at the school
<p>Physical</p> <ul style="list-style-type: none"> ▪ White boards ▪ Textbooks (<i>updated versions</i>) ▪ Internet access ▪ It support & infrastructure <p>Human none</p> <p>Other</p> <ul style="list-style-type: none"> ▪ No self-discipline-mathematics students do not do their mathematics homework ▪ Violence & gangsterism (security issues at school), leads to shortage of resources through theft & vandalism Students <p style="text-align: right;">Resources:</p>	<p>Physical</p> <ul style="list-style-type: none"> ▪ Green chalk boards ▪ Mathematics textbooks ▪ Paper video (disks contains mathematics worksheets) 	<p><u>Colleagues, Mathematics HOD & School Based Support team</u></p> <p>Mathematics teachers shares ideas and learning material (mathematics worksheets) with one another</p> <p>The mathematics HOD provides mathematics teachers with past examination mathematics.</p> <p>The mathematics HOD provides mathematics teachers with information on the latest developments in mathematics instructional methods</p> <p><u>Students</u></p> <p><u>Parental support</u></p> <p>Private tuition Motivate and encourage children to do mathematics homework</p> <p>Assist their children in finding organisations to assist them with the challenges they experience in mathematics</p>	<p>Mathematics magix: Mathematics software application</p> <p>Telematics (Vodacom): Mathematics online interactive computer programme</p> <p>Strengths:</p> <p>Maths Magix: A user-friendly computer application that provides easy, medium and difficult levels for both Practice and Test sessions in mathematics for all school Grade s. It tracks history of previous tests taken by an individual and displays level wise high scores along with average time taken per question. Gives scope for improving mathematics skill-sets of an individual.</p> <p>Telematics (Vodacom): The presenters explain core concepts and address problem areas in which students had experienced difficulty in previous examinations. All the broadcast is available on DVD or as part of the online video library, which is a powerful tool the teachers can use for exam revision.</p>
Lack	Access		

<p>Physical</p> <ul style="list-style-type: none"> ▪ Mathematics textbooks ▪ Lack of technological resources ▪ No computers ▪ No laptops ▪ Use of mobile application & the use of search engines (e.g. Google) prohibited on personal device in school time. <p>Human None mentioned</p> <p>Other</p> <p>Teachers limited knowledge & use of technology</p> <p>Teachers understanding & knowledge of the subject content.</p>	<p>Physical</p> <ul style="list-style-type: none"> ▪ Calculators ▪ Mathematics textbooks ▪ Projectors ▪ whiteboards 		<p>A major factor in the success of the project is the dynamic interaction that can take place between the presenters, working from the broadcast studio at Stellenbosch University, and the students watching via satellite or live Internet streaming all over South Africa. The students can ask questions via an interactive web page</p> <p>Limitations:</p> <p>Maths Magix: Requires private fees/funding</p> <p>Telematics (Vodacom): No Internet access/broadband connectivity</p> <p>Need to be expanded to more schools/areas with struggling mathematics students.</p> <p>Mathematics FET teachers</p> <p>WCED Reflect & Review meetings</p> <p>No other teacher support programmes mentioned</p> <p>Strengths:</p> <p>WCED Reflect & Review meetings</p> <p>Mathematics teachers share best practices particularly about the mathematics curriculum</p> <p>Limitations:</p>
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			<p>Ideas shared amongst mathematics teachers from various high schools are at times not applicable to mathematics students that are underperforming and come from impoverished back grounds.</p>
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Synopsis of participants with emergent themes for each school -SCHOOL D

Challenges in mathematics (students & teachers)		Type of mathematics support	Mathematics support programmes participants have access to and utilise
<u>Teachers</u> Resources:		<u>Teachers</u>	<u>Mathematics Grade 12 students</u>
Lack	Access	<u>Mathematics Curriculum Advisors (MCA</u>	No mathematics support programmes offered at the school
<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ None mentioned <p><u>Human</u></p> <ul style="list-style-type: none"> ▪ No IT support ▪ Shortages of qualified mathematics teachers <p><u>Other</u></p> <ul style="list-style-type: none"> ▪ Funds for mathematical resources ▪ Mathematics Curriculum (CAPS) content such as geometry and trigonometry are too abstract ▪ Mathematics teachers are required to set up the mathematics assessment 	<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Mathematics computer programmes ▪ Projectors ▪ Visual information-mathematics posters 	<p>Mathematics and Science Project (MSEP), an initiative of the University of Cape Town in collaboration with the Education Department-tutorial programmes offered to only a few schools that offer mathematics with the objective of improving mathematics performance at schools</p> <p><u>Colleagues, Mathematics HOD & School Based Support team</u></p> <p>No support</p> <p><u>Students</u></p> <p><u>Parental support</u></p> <p>Parents encourage their children to find assistance and learning material in mathematics at the local libraries and on the internet, such as printable resources</p> <p>Support in the form of constant motivation to do their best.</p>	<p><u>Mathematics FET teachers</u></p> <p>No teacher support programmes mentioned</p> <p>Strengths: none</p> <p>Limitations: Mathematics student and teachers are not timeously informed by the school principal of support programmes available at other schools.</p>
	<u>Students</u> Resources :		

Lack	Access	Parents constantly request of the school to provide extra mathematics tuition to the Grade 12 mathematics students	
<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Mathematics textbooks ▪ computers <p><u>Human</u></p> <ul style="list-style-type: none"> ▪ none <p><u>Other</u></p> <p>Questions received in the mathematics exams are not done in class</p> <p>Mathematics teachers' lack of effective teaching methods</p>	<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Mathematics textbooks 		

Synopsis of participants with emergent themes for each school -SCHOOL E

Challenges in mathematics (students & teachers)		Type of mathematics support	Mathematics support programmes participants have access to and utilise
<u>Teachers</u> Resources:		<p>Teachers</p> <p><u>Mathematics Curriculum Advisors (MCA)</u> On sight visits-provide mathematics teachers with information on interventions strategies for underperforming mathematics students</p> <p>Provides resources for the school, computers, additional learning material.</p> <p>Arrange access to e-learning.</p> <p><u>Colleagues, Mathematics HOD & School Based Support team</u></p> <p>Mathematics teachers shares information and mathematics printable resources/material</p> <p>Mathematics HOD provides information on mathematics workshops</p>	<p><u>Mathematics Grade 12 students</u></p> <p>Telematics (Vodacom): Offer interactive online mathematics support programme at the school (after school programme) – initiated by the Education Department</p> <p>Shawco: Saturday classes & workshops</p> <p>Strengths:</p> <p>Telematics (Vodacom): The presenters explain core concepts and address problem areas in which students had experienced difficulty in previous examinations. All the broadcast is available on DVD or as part of the online video library, which is a powerful tool the teachers can use for exam revision.</p> <p>Telematics (Vodacom): A major factor in the success of the project is the dynamic interaction that can take place between the presenters, working from the broadcast studio at Stellenbosch University, and the students watching via satellite or live Internet streaming all over South Africa. The students can ask questions via an interactive web page.</p> <p>Telematics (Vodacom): The use of technology, motivates mathematics</p>
Lack	Access		
<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Mathematic textbooks (damaged & outdated) ▪ Internet access ▪ IT Support <p><u>Human</u></p> <ul style="list-style-type: none"> ▪ none <p><u>Other</u></p> <p>none</p>	<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Mathematics computer programmes ▪ Computers ▪ Internet ▪ Geometry sets ▪ White boards ▪ Posters on mathematics topics ▪ projectors 		
<u>Students</u> Resources:			
Lack	Access	<p>Students</p> <p><u>Parental support</u></p> <p>Parents encourages and motivates mathematics students to do their best</p>	
<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Mathematics textbooks ▪ Projectors ▪ Classroom space <p><u>Human</u></p> <ul style="list-style-type: none"> ▪ None <p><u>Other</u></p>	<p><u>Physical</u></p> <ul style="list-style-type: none"> ▪ Computers ▪ Internet ▪ Mathematics printable resources 		

<p>The mathematics syllabus (CAPS)- limited time to complete mathematics content</p> <p>Mathematics teachers are absent a lot.</p>			<p>students to attend the interactive online mathematics support programme</p> <p>Telematics (Vodacom): Has shown observable improvements in mathematics literacy performance</p> <p>Shawco: Provide students with curriculum support in core academic areas, such as maths.</p> <p>Shawco: Students have access to the University of cape Town’s resources</p> <p>Limitations:</p> <p>Telematics (Vodacom): No observable improvements for existing underperforming mathematics students</p> <p>Telematics (Vodacom): No Internet access/broadband connectivity</p> <p>Telematics (Vodacom): Need to be expanded to more schools/areas with struggling mathematics students.</p> <p>Shawco: Requires private fees/funding</p> <p><u>Mathematics FET teachers</u></p> <p>No teacher support programmes mentioned.</p>
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