CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION AND BACKGROUND

A thorough understanding of mathematics is an asset if not essential for applicants interested in obtaining employment in South Africa. According to Steen (1989:19) mathematics does not only empower people with the capacity to control their lives but also provides science a firm foundation for effective theories, and also guarantees society a vigorous economy. At its most basic level mathematics is a requirement for science, computer technology and engineering courses. Seen from a social perspective, mathematical competence is an essential component in preparing numerate citizens for employment and it is needed to ensure the continued production of highly skilled persons required by industry, science and technology. Throughout the world a major difference between the advanced and the underdeveloped countries of today has been noted in their level of development in modern science and technology. There is thus a compelling need for South Africa as a developing country to keep up with new and emerging technologies. However, literature on the academic achievements and success of historically disadvantaged learners in mathematics is mostly about their academic failure. Since mathematics is a requirement for science, computer technology and engineering courses as well as for advanced mathematics courses, a low level of mathematics has become a barrier preventing many learners from pursuing careers related to these areas at tertiary institutions (universities or universities of technology).

Several studies conducted locally as well as internationally have highlighted certain shortcomings in the mathematical achievements of South African learners. In the Third International Mathematics and Science Study (TIMSS, 1997) seventh grade and eighth grade learners in South Africa were ranked last in mathematics out of 41 participating countries. They achieved a score of 348 for seventh grade learners compared with the international mean score of 484. In the eighth-grade the score was 354, compared to the international mean of 513. Furthermore, in a joint survey conducted by the Foundation

for Research and Development and the Human Sciences Research Council, it was stated that South Africans ranked 18th out of 20 world nations on natural and environmental sciences (Calendar, 1998). Regarding the performance of learners in the South African grade twelve examinations, the Limpopo Province (where this study was conducted) produced the poorest or second poorest matriculation mathematics and science results out of nine provinces for the past five years (Strauss, Plekker & Van der Linde, 1999).

Although South African learners are not performing well in mathematics internationally and locally, the situation is even worse among black learners (Brodie, 2004). For example, the failure rate for black Grade 12 learners in mathematics in 1999, 2000, 2001 and 2002 was 88.3%, 84.5%, 80% and 76.8% respectively (Kahn, 2001).

According to Kahn (2001) this data indicate that the number of higher grade mathematics passes for black learners is around 3000 per year. This current pool thus serves as the source for tertiary institutions' graduates in science, engineering, technology, and mathematics professions among the black population. The National Commission on Higher Education (NCHE, 1996) supported this finding in their documents when they stated that South African blacks are underrepresented in the scientific, engineering and mathematical professions. Furthermore the report of the South African Institute for Race Relations, showed that in fields such as commerce, mathematics, and engineering there are two non-black graduates for every black graduate (http://allafrica.com/stories/200112110604.html).

In view of the importance of mathematics in society, the preceding discussion raises serious concern among educators and policy makers, firstly, because these learners comprise the majority of high school learners in South Africa (Maree, 1997). Hence this will affect the quality and quantity of human resources of the nation as a whole. The underperformance of learners in mathematics in high schools is also of concern to the instructors at tertiary institutions. The most obvious reason why school mathematics education should matter to university instructors is that a continuing influx of mathematically incompetent students would lower standards in the university

mathematics curriculum (Wu, 1997). Secondly, several studies (Peng & Hill, 1995) show that high school graduates (matriculants) with low achievement in science and mathematics, who continued their education after high school, were less likely than other students to register for science and mathematics-oriented fields at the university.

Although the above information may not represent a complete picture of mathematics education in South Africa, it certainly indicates that mathematics education is not in a healthy state. However, the above picture conceals the outstanding performances in mathematics of some historically disadvantaged learners and from whom one would not expect much in the way of success (Department of Education, 2000a).

In an effort to identify the causes for low achievement in mathematics, some researchers (Attwood *et al.*, 2001, Brodie, 2004, Maree, 1997, Murray, 1997) have suggested that achievement in mathematics in secondary schools is influenced by a number of variables. These variables include learners' abilities, attitudes and perceptions, family and socio-economic status, parent and peer influences, school-related variables such as poor learning environment, learning cultures, past racial discrimination and low expectations by principals and teachers. Such factors alone cannot account for the lack of mathematics achievement and persistent differences among traditionally disadvantaged learners. In particular these explanations fail to account for intragroup achievement differences and the success of some South African disadvantaged learners in spite of these background factors. Some well-achieving disadvantaged learners come from the same communities and share similar socio-economic backgrounds, schools and classrooms. According to Singh *et al.* (2002) many of these variables are home and family-related and thus are difficult to change, and outside the control of educators.

In traditionally disadvantaged schools, let alone in Grade 12 classes, learning difficulties in mathematics could originate from the learners' under-preparedness, the teacher's presentation of the subject matter, knowledge of the role of mathematics in future career opportunities, or difficulties in the classroom situation or mathematical language. These are some of the school-related variables that can be addressed. Since mathematics is

mainly taught in the classroom, observation of classroom practices may throw more light on some of the factors that facilitate achievement in traditionally disadvantaged secondary schools.

1.2 THE MAIN RESEARCH PROBLEM

Mouton (1996) believes that research begins with reflection, which includes unstructured thoughts, assumptions and questioning. This reflection can be seen as a run-up to the development of a research problem.

The central research question to be addressed in the study is:

What factors facilitate achievement in Grade 12 mathematics in traditionally disadvantaged schools, particularly in Limpopo Province?

This study therefore seeks to identify the characteristics, similarities and differences of the selected high- and low-achieving schools in mathematics with similar learners' backgrounds.

1.3 FORMULATION OF THE RESEARCH QUESTIONS

In any scientific study the research problem has focus, direction and an element of planning. Relevant questions focus the researcher's attention on the aspects that should be scientifically described. This will provide a direction factor for the study (McMillan & Schumacher, 2001).

In order to start any realistic attempt to trace factors that facilitate achievement in mathematics in traditionally disadvantaged secondary schools, a thorough investigation will first be conducted to detect the possible causes of what is perceived to be a very poor

situation. Moreover, in an attempt to gather more information concerning the research problem, this study will seek to find answers to the following questions:

RESEARCH QUESTION 1
What are the attitudes and competencies of mathematics teachers in high-performing and under-performing schools?

RESEARCH QUESTION 2
What are the learners' attitudes towards mathematics and their perceptions of their successes and/or failures in mathematics?

RESEARCH QUESTION 3
What factors facilitate successful classroom practices in mathematics in Grade 12 schools?

Hopefully, this study will stimulate public school administrators, teachers and others to investigate new ways of helping disadvantaged learners to achieve better results in mathematics. Secondly, through research we endeavour to explain some disadvantaged learners' success in mathematics. In addition disadvantaged learners need to know why some of their peers are successful.

This study focuses in particular on the role of the teachers as agents of mathematics socialization, including their beliefs and goals for disadvantaged learners; the reasons for their particular way of teaching, specifically their ideas about mathematics and its value and usefulness, and what they consider as vital in mathematics teaching, particularly in grade 12 classes.

Secondly this study is particularly concerned with establishing whether learners will still want to continue with mathematics at tertiary level after their grade twelve experiences,

including their affinity for mathematics, focus on their future plans, perceptions of mathematics, beliefs regarding mathematics and its usefulness, and their beliefs concerning success and failure in mathematics, and most importantly the role of peers in mathematics socialisation.

Thirdly this study concerns the teachers' attitude towards their learners as well as their explanations of learners' successes and failures in mathematics.

Lastly this study concerns establishing the way in which classroom practices serves as contexts that promote positive or negative mathematics beliefs for achievement and persistence.

1.4 EXPECTED OUTCOMES OF THE STUDY

Factors that contribute to better achievement in mathematics of learners in traditionally disadvantaged schools will be identified and studied. The methods that will be used to achieve this aim are focus group interviews, classroom observations and individual interviews with the selected students and teachers.

Despite an abundance of literature that describes failure among disadvantaged learners in mathematics, very little research explains why some of these students succeed in mathematics, and why they do so at levels comparable to those of their peers in other groups. Hence, by comparing mathematics teaching and learning in schools with similar backgrounds, indication of why the school is achieving above or below expectation in Grade 12 mathematics can be determined on the basis of its characteristics. . Furthermore, if this research could determine factors that facilitate achievement in mathematics in traditionally disadvantaged schools, it could create opportunities for those who would otherwise fail. Findings from this study should also begin to fill a void of knowledge, while adding understanding that could lead to useful activities to persuade more students from traditionally disadvantaged backgrounds to develop their full potential in mathematics.

1.5 SIGNIFICANCE OF THE PROPOSED STUDY

Firstly, in identifying factors that facilitate achievement in mathematics in a traditionally disadvantaged school, policy makers and mathematics educators could possibly be assisted in formulating strategies aimed at improving the performance of learners from traditionally disadvantaged backgrounds. Secondly, since the highest percentage of high school learners living under poor social and economic conditions are found in the Limpopo Province (Zaaiman, 1998), this study anticipates that more than socio-economic variables influence the mathematics achievement of disadvantaged secondary school learners. Thirdly, the findings of this study will be important to professionals working with similarly disadvantaged learners as well as with those who want to enhance their understanding of the factors that facilitate mathematical achievement among disadvantaged learners.

1.6 MOTIVATION OF THE STUDY

The researcher's own interest in this study derives from serving previously as a high school mathematics teacher employed by the Department of Education and currently a trainer of teachers and a university lecturer. During his career the researcher taught mainly mathematics to high school learners or prospective mathematics teachers. Moreover, the University of Venda, at which the researcher is an instructor, has been conducting winter upgrading courses for mathematics and science high school teachers since 1997. This programme is aimed at assisting teachers in improving their knowledge of mathematics and science. The researcher is responsible for teaching the mathematics part of this programme.

1.7 MOTIVATION FOR SELECTING GRADE 12 CLASSES

This study focuses on Grade 12 because of the following reasons:

- Grade 12 teachers are expected to be fully committed to teaching as learners are preparing for school-leaving examinations. Moreover many of the learners will want to enter tertiary educational institutions such as universities or universities of technology and are also expected to be committed.

- Secondly learners in Grade 12 are likely to have formed their opinions regarding mathematics and would have experiences to share.

- Thirdly, secondary schools in South Africa are mostly classified as effective or ineffective on grounds of the level of learners' achievements in the Grade 12 examination results.

1.8 RESEARCH DESIGN OVERVIEW

According to Cormack (1996), the research design represents the major methodological thrust of the study, being the distinctive and specific approach, which is best suited to answer the research questions. The research questions, the aim and the objectives of the study thus influence the selection of the research design (Brink, 1999).

The purpose of the research design, as stated by Burns and Grove (2001), is to achieve greater control of the study and to improve the validity of the study in examining the research problem. For the research design of this thesis the following are specified, namely:

- Data collection strategies

- Sampling strategies

- Participants in the study

- Data analyses strategies

- Triangulation

1.8.1 Data collection and analysis strategies

This study will be exploratory and descriptive involving qualitative and quantitative data gathering in the form of:

- Six weeks of classroom observations.

- Repeated focus group interview sessions with teachers and students separately.

- Analysis of audiotapes and videotapes of some lessons and focus group interviews.

- Analysis of questionnaires completed by both teachers and students in Grade 12.

1.8.2 Triangulation

Neuman (1994:141) defines triangulation as "the use of two or more methods of data collection techniques, in order to examine the same variable". The ideal with triangulation is that measurements improve when diverse indicators are used. As the diversity of the indicator increases, confidence in measurement grows, because obtaining indicator measurements from highly diverse methods results in greater validity. Triangulation techniques attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one angle, thus making use of both qualitative and quantitative data. According to Cohen and Manion (1997) triangulation is appropriate in the following instances:

- when a more holistic view of educational outcome is sought;
- where a complex phenomenon requires elucidation;
- when different methods of teaching are to be evaluated;
- where a controversial aspect of education needs to be evaluated more carefully;
- when an established approach yields a limited and frequently distorted picture;
- where a researcher is engaged in a case study.

Triangulation will be used in this research.

1.8.3 Sampling strategy

For the purpose of this study a purposive or judicious sample will be used. This type of sample is based entirely on the judgement of the researcher, in that a sample is composed of elements that contain the most characteristic, representative or typical attributes of the population (Neuman 1994, Strydom & De Vos, in De Vos, 2001).

The subjects of this research will be Grade 12 teachers and learners from historically disadvantaged schools from similar backgrounds. Gender is not relevant. In order to obtain a sample with a range of mathematical skills, teachers will be requested to select learners according to their performances in the grade 11 mathematics final examination. One high-achieving learner score of at least 75%, one middle-achieving learner (score between 40% and 60%), and one low-achieving learner score, at most 40%, will be

selected. If there are no learners who scored more than 75% in the schools chosen, then all three learners will be correspondingly chosen on the basis of their examination rankings as compared with other learners in the class. Finally, subjects should be willing to participate in the study.

1.8.4 Participants / respondents[1] in the study

The study will be conducted in Vhembe district of the Limpopo Province, and in particular in the Soutpansberg area. The Soutpansberg area has sixty-five secondary schools. A total of four classrooms from four schools involving Grade 12 learners were selected for Phase 1: *Classroom observation* of the study. Four teachers were involved in Phase 2: *Focus group interviews*; two from well-performing schools in mathematics (ranked top five for the past three years) and two from under-performing schools in mathematics (ranked bottom five for the past three years). Furthermore, eighteen learners in total from ten schools (five high-performing, five low-performing) were asked to participate in Phase 2 of this study, classified as best, average and below average learners. For Phase 3: *Quantitative data* a total of ten schools were selected, five high-performing and five low-performing schools (mentioned above).

1.9 ETHICAL CONSIDERATIONS

Ethical considerations are of the utmost importance when one is conducting research (Strydom in De Vos, 2001). The researcher accepts the assertion that research contributes to scientific knowledge and that human and technological advances are based on this knowledge. In particular, it is accepted that educational research should contribute to better the scholarship of teaching and the development of the learner. The researcher agrees with Strydom (2001: 23-35) that the following should be observed:

- *Gaining of consent from the participants.*
- *No deception on the part of participants.*
- *No violation of the participants' privacy.*

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[1] The word "participants" applies to the qualitative sections of my study and the word "respondents" to the quantitative sections.

- *Release and publication of the findings in an accurate and responsible manner.*

In view of the above ethical considerations the researcher observed the following:

1.9.1 Permission

Permission to conduct research in Region 3 has been sought from the Regional Director. (Letters requesting permission and their replies can be found in Appendices A and B, respectively).

1.9.2 Appointments

Letters were posted to the principal of each selected school, followed by visits and appointments to conduct interviews or submit questionnaires. Group meetings were held with the teachers and learners to explain the research project and the process.

1.9.3 Confidentiality

All respondents will be assured of confidentiality by means of a written notice. Participants will be given a pseudonym to protect their identities and to ensure confidentiality.

1.9.4 Post-research relationships

The research report will be made available to the Special Collection Section of the University of Venda for Science and Technology and to the University of Pretoria where respondents would have access to it.

1.10 DEFINITION OF KEY CONCEPTS

An explanation of the title, namely, t*racing factors that facilitate achievement in mathematics in traditionally disadvantaged secondary schools,* will explain the meaning of the terminology involved as it is applied within the context of this study. Other terms used in this study will be defined as they occur.

1.10.1 Disadvantaged learner

According to Sarason (1993) researchers investigating the subject-disadvantaged learners must operationally define this population. In this regard several researchers (Gordon, 2004, Levin, 1995, Pallas, 1989) have used a variety of definitions, usually selecting some subgroup from this diverse population. For example Levin (1995) has defined disadvantaged learners as learners who lack the home and community resources to benefit from conventional schooling practices.

According to Gordon (2004) the term "disadvantaged learners" refers to a group of learners which differs from other terms in a number of ways, but has in common characteristics such as 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. In a similar way the British National Commission on Education (BNCE, 1996) defined educational disadvantage learners as those learners denied equal access to educational opportunities, the tendency of the learners to leave education at the first opportunity, and the hindrance of achievement by social and environmental factors.

In order to construct a reliable and dependable definition of disadvantaged learners, several characteristics are taken into consideration. Such characteristics, commonly associated with disadvantaged learners, are low socio-economic status, isolation, rurality, low ethnic group status, second language problems, family breakdown, violence and peer group and gender problem (Zaaiman, 1998).

For the purpose of this study the term "disadvantaged learner" will be used to denote those learners whose environment does not transmit to them the necessary values for success in school.

1.10.2 Factor

A factor is defined as one of the elements contributing to a particular result or situation (Costello, 1992). By factors the researcher refers to the elements that contribute to good achievement in mathematics by learners from disadvantaged backgrounds.

1.10.3 Effective learning

According to Mwamwenda and Mwamwenda (1987) effective learning is defined as the learning that takes place when learners learn according to their needs and understand the subject matter. Smith (1998) views effective learning as the learning that requires learner's involvement and it often best takes place when learners have the opportunity to express ideas and obtain feedback from their peers. For the purpose of this study effective learning means learning that leads to improved learners' achievement in mathematics, but not mere memorization of tasks by learners. In Chapter 2 an overview of effective learning relevant to the focus of this study is given.

1.10.4 Learner

Currently the term "learner" is preferred to the term pupils although the two are regarded as synonyms. Since one should guard against the use of so-called "buzz-words" the trend is to use the word "learner" instead of "pupil" within the context of this study (Maree, 1997). Both words are derived from and related to different languages (Gove cited in Maree, 1997). The word "learner" can have the following meanings: persons who learn; persons preparing for a particular subject; person who through lengthy and systematic study attain a high degree of expertise, skill and efficiency; persons who have the following attitudes or characteristics: curiosity, perseverance, initiative, originality, creativity and integrity. These characteristics are precisely those that are regarded as essential for achievement in mathematics. For the purpose of this study learners refer to persons who are scholars or are engaged in some or other form of high school mathematics study.

1.10.5 Achievement

Gove (in Maree, 1997:15) defined the term "achievement" as follows:

> *A result brought about by resolve, persistence and endeavour; performance by a student in a course; the quality and quantity of a student's work during a given period; or the capacity to achieve a desired result; the manner of reacting to various stimuli.*

Achievement may also be defined as the mastering of major concepts and principles, important facts and propositions, skills, strategic knowledge and integration of knowledge (Niemi, 1999). For the purpose of this study the word "achievement" indicates the learners' level of self-fulfilment in mathematics, as well as their ability to attain particular levels of achievement in mathematics through exertion and perseverance.

1.10.6 Secondary school mathematics

Secondary school mathematics refers to mathematics that is taught in Grades 7 to 12, which might be broadly conceived of as mathematics beyond arithmetic and the basics of measurement and geometry.

1.11 THE ROLE OF THE RESEARCHER

In qualitative research the researcher has an important role to play. The researcher agrees with Schurink (in De Vos, 2001: 261) that the following rules should be observed:

- Making sure that the environment is not contaminated (e.g. by tape recorders and video cameras), especially not without the permission of subjects.
- Answering questions as honestly as possible.
- Avoid unnecessary, technical information that could confuse subjects about the research.
- Being very sure of the aims of your research and how you intend achieving them
- Observe ongoing social processes without disrupting or imposing an outside point of view.

It was therefore very important that I fulfil all the necessary roles, if the research is to be conducted successfully.

1.12 LIMITATIONS AND ASSUMPTIONS OF THE RESEARCH DESIGN

The limitations on which the present study is based are as follows:

- This study is confined to Grade 12 mathematics learners and teachers and does not include those from lower grades. It is envisaged that factors that facilitate achievement in Grade 12 mathematics learners will also apply to learners in lower grades.
- Although there may be many factors that facilitate achievement in mathematics, this study will be restricted to those factors that are not beyond the control of educators. This decision is based on the fact that certain factors might be home and family-related and these can be very difficult to change.
- The study concentrated on schools that were found in disadvantaged areas at least 20 kilometres from Makhado.

Lastly, the situation might arise that some teachers who are to be observed, will not feel comfortable about being videotaped, especially those from underperforming schools. In such a case the researcher will then be forced to choose another teacher to observe and this might delay the research process. Secondly, the focus group interviews allow the participants to influence, and interact with one another and consequently they are able to influence the course of the interview.

1.13 SUMMARY AND CHAPTER DIVISIONS

CHAPTER 1

In Chapter 1 a broad orientation of the study, including an introduction to the study is discussed. The title is explained, the research approach followed in the study is outlined and the researcher's view on ethical considerations is highlighted.

CHAPTER 2

Chapter 2 is an overview of related literature on factors that facilitate achievement in mathematics.

CHAPTER 3

In Chapter 3 a description of the research design and methodology of the study are discussed.

CHAPTER 4

Chapter 4 consists of a case study of classroom observations and focus group interviews.

CHAPTER 5

An analysis and interpretation of the learners' quantitative data are presented in Chapter 5. Comparisons are made between learners from high-performing schools and low-performing schools on factors that facilitate achievement in mathematics.

CHAPTER 6

In Chapter 6 analyses and interpretation of teacher data is presented. This includes an explanation of factors that facilitate achievements in mathematics from the teachers' point of view. Comparisons are made between teachers from low-performing schools and high-performing schools on factors that facilitate achievement in mathematics.

CHAPTER 7

In the final chapter (Chapter 7), the researcher's findings and conclusions as well as the implications of the study are discussed. Recommendations for future research have also been made.