Science and Mathematics Education Centre

Secondary Mathematics Teachers' Classroom Practices: A Case Study of Three Township Schools in Gauteng Province, South Africa

Mapula Gertrude Ngoepe

This thesis is presented for the degree of
Doctor of Mathematics Education
of
Curtin University of Technology

May 2003

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Signature: ....

Date: ....

ABSTRACT

While there have been enormous changes in the South African system of education since 1994, the legacy of apartheid and the different education of Black teachers is still evident in township schools. This study examined the practices of mathematics teaching in three township secondary schools by conducting a detailed investigation of eight teachers in three schools. Classroom observations and video recordings of teachers of Grades 10 to 12 served as the main data collection method. A sample of 12 lessons was analysed using the Secondary Teaching Analysis Matrix-Mathematics (STAM-Mathematics) (Gallagher & Parker, 1995) instrument. The researcher used STAM to categorise teachers' classroom practices along a three pronged continuum, namely didactic, transitional and conceptual teaching for the purpose of answering research questions about the content, the teaching, the assessment practices, the interactions between the teacher and the student, and the resource availability.

Analysis of the data collected using the 22 STAM descriptors showed that the practices of teaching mathematics in township secondary schools was primarily didactic, with only minimal characteristics of transitional teaching and fewer attributes of conceptual teaching. Identifying the gaps between the teachers' practice and the descriptors for transitional and conceptual teaching with respect to the content, the teaching, the approaches to assessment, interactions between teacher and students, and resources availability has provided insight and a baseline for teacher in-service. Consequently, this study has provided research-based evidence for appropriate intervention to improve mathematics teaching and learning as prioritised by the Department of Education since the creation of the democratic government in 1994. It is recommended that mathematics teachers in township schools use the STAM instrument in pairs or groups to observe and analyse each other's lessons with particular focus on the 22 descriptors and to use this framework as a guideline for daily lesson preparations and to help guide the teachers from teacher-centred instruction to conceptual instruction. Further, the STAM could be incorporated into teacher education and professional development programs and thereby lead to more conceptual forms of teaching that could contribute towards a greater understanding of mathematics and ultimately raise the pass rate of learners in external examinations at Grade 12.

DEDICATED TO

Phuti, Reamogetje, Noko and Magashe

my children, who sacrificed, interceded and understandingly endured the absence of mummy in the house, yet without complaint.

Thabo

my husband, whose love, support, encouragement and intercessions enabled this work to be completed.

Bakone, ke leboga thekgo ya lena go menagane

ACKNOWLEDGEMENTS

I am grateful to God, the Almighty, without whose guidance through the Holy Spirit this work would not have been accomplished.

Many thanks to my supervisor Professor David Treagust whose positive attitude and patience was a great source of motivation and encouragement to keep going. His extra willingness to help amidst his busy schedule served as a model of dedication, commitment and desire for student success.

Professor Diane Grayson provided an opportunity for this study to be conducted. Her desire for and interest in research in mathematics, science and technology education served as an inspiration for instilling enthusiasm for me to conduct research in mathematics education.

The financial support of UNISA management— Professor Mofokeng, Mr Moloto and the encouragement of Professor Salbany—is greatly appreciated.

I am indebted to the spiritual support of my mothers Mologadi Mogashoa, Ntlakadi Ngoepe and Pamela Mojela.

This thesis could not have happened without the National Research Foundation, through the auspices of Dr Kopano Taole, whose vision to establish a culture of research in mathematics, science and technology education made a dream come true, and the continued support of the NRF through the current manager, Mrs Beverly Damonse.

Sincere thanks for the support of Curtin staff, my doctoral colleagues and all my loved ones. Finally, I am grateful to the Department of Education and the teachers who participated in this study.

TABLE OF CONTENTS

CHAPTER 2: LITERATURE REVIEW

CHAPTER 4: RESULTS

CHAPTER 5: SYNTHESIS, RECOMMENDATIONS AND CONCLUSIONS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

RATIONALE OF THE STUDY

"...In an enterprise such as education...research is the best hope we have of distinguishing between fads and facts, prejudices and informed judgements, habits and insights. Without systematic inquiry, development, and testing, we will continue to have the same babble of arguments and practices concerning what works or ought to work. Without good research, we will continue on an endless cycle of mistakes... an endless reinvention of mousetraps, the same rehashing of controversies, and in the end, the same faltering school system". (Shanker, 1999, p. 931)

1.0 Introduction

This study investigates the practices of mathematics teachers in township secondary schools in South Africa. Specifically, this study sought to identify and characterise the teaching used by secondary mathematics teachers in three township schools. The introduction of the chapter starts with the personal reflections of the author as a learner and teacher in South Africa to provide background to the need for research-based information to transform the teaching and learning of mathematics. The research problem and research questions that guided the study are provided. The significance of the study is addressed, limitations are identified and the outline of the thesis and a summary concludes the chapter.

1.1 Personal reflections of a mathematics learner and teacher in South Africa

1.1.1 Primary education

My education under the apartheid system of Bantu Education started with primary schooling at a farm-school. The school was a hall that was also a community centre used for church services and other functions. The hall was partitioned into three to accommodate classrooms that combined Sub A and B (Grades 1 and 2), Standards 1 and 2 (Grades 3 and 4), Standards 3, 4 and 5 (Grades 5, 6 and 7) with three teachers. Although I remember little about my primary education, one incident that is still clear is that when our teacher wanted us to know our mathematics tables and to be sure that we learnt these, we were not allowed to go for lunch break/short break unless we could recite them. This motivated us to learn our tables. The education system at that time led to three certificates at Standard 6 (Grade 8), Standard 8 (Grade 10) and at Standard 10 (Grade 12). The school that I attended did not have Standard 6, so I did this at a co-educational primary missionary school.

One of my experiences that related to mathematics education in my primary school years was when I was in Standard 2 (Grade 4). I had to leave my parents home to go and live with my grandfather and help to cook, fetch fire wood, water and attend school. In the first six months away from my parents, I had very little schooling that year, but went to herd the cattle and horses of the family of one of my friends. This school was build by the community and had two blocks – one block partitioned to accommodate learners of Sub A and B and Standards 1 and 2, and a separate block for learners in Standards 3, 4 and 5. A neighbouring friend informed my parents about my not attending school and I was taken back to my parents' home. I could not deal with the mathematics at Standard 2 (Grade 4) on return to my farm school, and with her Standard 6 knowledge my mother taught me how to do basic arithmetic.

1.1.2 Secondary education

My secondary education was at a missionary school. The subjects Agriculture (Landbou) in Grade 9 and Mathematics Grades 8-12 were through the medium of Afrikaans. For my matriculation certificate my subjects were the three languages- Northern Sotho, Afrikaans and English, Biology, Geography and Mathematics. There was no Physical Science taught at this school. We did not have an English version of a Geography textbook during the year, so our teacher used to translate for us from an Afrikaans textbook. We only received the textbooks towards the end of the year when we were revising for our Matriculation examination.

I wrote my Standard 10 in 1976 when there was violence throughout South Africa which was intense in the townships of the major cities in opposition to Afrikaans being used as a medium of instruction. However, these events did not disrupt much of our learning at the school which was far away in the countryside and most of us were unaware of what was happening in the cities since we did not have access to the media. However, on the 16 June, a group of people came into the schoolyard shouting "power" and we all ran away in different directions for cover. Some learners out of terror, ran into the bush, were injured and spent the night in the wilderness. Most of my school friends were not successful in the Standard 10 examinations that year, partly because of the emotional turmoil associated with some of their next of kin who were adversely affected by the violence, but I passed.

1.1.3 Tertiary education

In 1977, I was admitted to the University of the North for a BA degree and I did a one-year course in mathematics. During those times, this was a course that was specially offered for teachers who would qualify to teach mathematics in secondary schools. Also, I had to learn the equivalent mathematics terms in English because I had been taught in Afrikaans in my secondary education.

Students who enrolled for the arts were not allowed to major in mathematics because this was regarded as a science subject. After completion of my 3-year BA degree, I enrolled in a University Education Diploma (UED) specifically designed for a professional teaching certificate. The mathematics course in my BA degree enabled me to do a methods unit in mathematics teaching that covered Grades 8-12 mathematics syllabuses. I did not pass the unit on the methods of mathematics teaching until the end of the year after I had started teaching.

1.1.4 My first experience with mathematics teaching

In 1982, I was appointed to a teaching position at a secondary school in Polokwane, at Ga-Mothapo in the Limpopo Province. As a university graduate in that first year of my teaching, I taught Grade 11 and 12 mathematics to learners who did not have a teacher in the previous year. I had 35 periods per week and taught morning and afternoon lessons to help the learners catch up with the syllabus. The situation meant that the Grade 12 learners had to study a two-year syllabus in one year.

During the time that I taught the subject to my learners, I was able to pass my course: I really understood much of the mathematics when I started teaching. In this very first year of my teaching, the Education Department decided to cut the payment of teachers whose school results in mathematics were poor. Unfortunately, I was a victim of this government strategy to solve the problem of failure rate in mathematics at Grade 12.

When I got married in my third year of teaching, I left for another school were I taught Biology (Grade 11) and Agriculture Grade (12). Although, I was not qualified to teach these subjects, I was appointed to the position because the post was near to my new home. I then faced the challenge of teaching Biology which I learned in Grade 12 and Agriculture, which I only learnt in Grade 9 through the medium of Afrikaans.

1.1.5 Teachers College

Having taught in high school for three years and being the holder of a university degree with a professional qualification in mathematics education, I was next appointed to a position as a lecturer at Kwena Moloto College of Education in Polokwane at Seshego in the Limpopo Province. In the position, I trained junior primary and senior primary student teachers, and later secondary teacher trainees in the secondary programme which was introduced in 1988. Initially, there was no secondary teacher training in mathematics at the college because there were no staff members to teach mathematics for secondary teachers. Mathematics was a compulsory subject for student teachers of junior and primary schools since they were going to teach the syllabus as was prescribed by the Education Department and Training which was responsible for setting the final examination papers.

Student teachers were taught a methods course that exposed them to the different methods of teaching mathematics and also exposed them to the different teaching aids that could be used and how to design their own teaching aids as practicing teachers. The teaching style that we used was mostly teacher-led. In addition to the prescribed textbook, we compiled notes and handouts and exercises for our students based on the syllabus topics so that we could complete the syllabus. However, this approach encouraged the style of teaching that drilled students for examinations with question papers. The assignments that were given to students were in the form of problems that they had to solve, to define and explain the underlying concepts. In the methods course, students were given projects and assignments that involved designing teaching aids. For their teaching experience lessons, possession and use of teaching aids in the lesson presentation contributed to better marks in the lesson assessment.

In 1983, I enrolled for a part time BEd course at the University of the North. This course did not have a research component that would lead to a research report. As a mathematics lecturer, I attended several mathematics conferences as a result of invitations sent to mathematics lecturers but I did not present any papers because I did not know what to present at that time and we did not have any involvement with university lecturers who conducted research.

My involvement with research only started upon enrolling in my MEd degree in Mathematics Education at the University of Birmingham in England in 1988; I graduated in 2000. After attending a lecture on the attitudes towards mathematics, I became interested in investigating the attitudes of my student teachers towards mathematics learning and teaching. This experience with the student teachers prompted me to complete my MEd research dissertation on the attitudes towards mathematics learning and teaching. This area of interest was because I had observed students' attitudes towards mathematics which was manifested in their behaviour of missing classes, dragging their legs to mathematics lessons, failing the courses and also confessing that mathematics was difficult. Consequently, a 40-item questionnaire was sent to South Africa to my students even though the study was done while I was resident in England.

Having been educated and trained under the South African Education system of apartheid, I would say that my education and training did not make me be a better mathematics teacher but the effort that I put into and my interest in mathematics did.

1.1.6 Research experience

Consequently, my interest in research was grounded in my MEd dissertation that resulted in my first presentation and publication at the annual meeting of the South African Association for Mathematics, Science and Technology Education (SAARMSTE) in 1998. Now I was motivated to pursue research in mathematics education (Ngoepe, 1998a). In 1997, when the College of Education where I worked was rationalised, I was employed as a Research Assistant at the Mathematics, Science and Technology Education College (MASTEC) to do research in mathematics, science and technology education (MST) and later I was appointed as a Lecturer in Science Education. From part of the data that I analysed for my work, I wrote a paper that resulted in my second publication at SAARMSTE (Ngoepe & Grayson, 2000). After three years of operation, MASTEC closed and I was employed as a research assistant in the Faculty of Science under the guidance of Professor Diane Grayson at The University of South Africa (UNISA) to conduct research that would lead to improvement in mathematics science and technology (MST) education. Recently, the Centre for the Improvement of Mathematics Science and Technology Education (CIMSTE) through the sponsorship from the Carnegie Corporation of New York has been established in the Faculty of Science to focus on research and teacher development.

1.1.7 What prompted me to conduct this study of investigating the teaching and learning of mathematics in township schools in Gauteng, Pretoria?

My interest in problems regarding the teaching and learning of mathematics has been influenced by my career as a secondary school mathematics teacher, as a mathematics educator, and recently as a researcher of mathematics education. The idea for investigating the practice of mathematics teachers in township schools was prompted by my involvement in research as part of my job prescription at UNISA. Part of my role as a researcher was to collect and analyse data that would provide baseline information for guiding professional development interventions. Data were collected in the form of questionnaires on professional attitudes, classroom observation, video and audio interviews of mathematics teachers and learners of Grades 10 to 12 in a township in Gauteng Province of South Africa. This data collection process was done with the aim of providing research-based information that would guide improvement in mathematics science and technology education (MST) for educators who are currently teaching in secondary schools. An analysis of the classroom observations resulted in two presentations at the Australian Association for Research in Education (AARE) (Ngoepe, Grayson, & Treagust,

2001) and the International Psychology of Mathematics Education (PME) (Ngoepe, 2002). These analyses revealed that there were various problems related to, for example, content knowledge, teaching styles, pedagogical content knowledge and various other issues. Informed by these analyses, it was deemed essential to further investigate the teaching of these township mathematics teachers' classroom practices. Informed by the literature, and discussions with my supervisor, Professor David Treagust, the Secondary Teaching Analysis Matrix-Mathematics (STAM-Mathematics) (Gallagher & Parker, 1995) was used in this doctoral study because it encompassed issues regarding the content, teaching, interactions, assessment and resources that I deemed worth investigating. The research is still ongoing.

1.2 Background to the study

The Bantu Education Act of 1953 was aimed at providing separate and unequal education for different races of South Africa (Nkabinde, 1997). The consequences of this were inferior education, unequal distribution of resources, crowded classrooms, poor teacher training, poor matriculation results and underqualified teachers among the Black people of South Africa (Arnott & Kubeka, 1997; Bansilal, 2002; Gray, 1995; Rollnick & Kahn, 1991).

The poor performance of South African mathematics and science learners has been well documented (See section 2.1.3). The Human Sciences Research Council conducted the Third International Mathematics and Science Study (TIMSS) and reveals the extent of the historical educational background of South Africa's legacy. The study comprised of a total number of 15 000 South African learners from more than 400 primary and secondary schools during 1994/1995 (Howie, 1997). Out of the 41 countries that participated in the study, South African learners scored the lowest of all the participating countries.

The TIMSS was repeated (TIMSS-R) in 1998 with tests and questionnaires administered in 38 countries (Howie, 2001). More than 8000 Grade 8 learners were assessed in 200 schools and more than 350 teachers and 190 principals of those schools participated. A total of 225 schools were selected at random from all the nine provinces of South Africa; 194 schools and 8147 learners were included in the international dataset for analysis. South Africa achieved a response rate of 85% and this national sample was representative for the country. In this TIMSS-R, South African students again performed poorly when compared to other participating countries. Out of 800 points, the average score of 275 was significantly below the average scores of all other participating countries.

Whilst there are many factors that may have influenced these results, it is well known that teachers play a critical role regarding learners' performance. The Minister of Education, Professor Bengu, acknowledged this challenge facing South Africa in the 21^{st} century as to how to improve the teaching and learning of mathematics and science. The teacher is the key to the ultimate educational changes and school improvement. The knowledge, skills, habits, professional attitudes of our teachers are most vital educational resources. It is what the teachers know, what they think, believe, value and do at the level of the classroom that will ultimately shape the kind of learning to which learners are exposed (Department of Education, 1997a).

Naruto University is part of a Japanese International Cooperation Agency (JICA), which supports collaboration between Japan and the Department of Education in South Africa and the University of Pretoria aimed at professional development for secondary school mathematics and science teachers. As a result of this collaboration, a pencil and paper baseline study of South African teachers' content knowledge was conducted in 1999 with a sample of 54 secondary school science and 60 mathematics teachers. Most of the material was based on the aspects of the Japanese Grade 9 and 10 syllabuses, although some questions were at a lower level. The average mark that the teachers' scored was 46% for science and 50% for mathematics (Nagao, Hattori, Kita, & Ono, 1999). This result might not be surprising as Arnott and Kubeka (1997) indicated that in 1995 over 50% of mathematics and science teachers were not formally qualified to teach these subjects. More information on teacher qualifications and training in South Africa are provided in Chapter 2.

According to Arnott and Kubeka (1997), the most serious charge that can be laid at the door of Bantu education is that it discouraged those qualities regarded as essential for sustainable development and success as a new millennium approached. These qualities included risk-taking, a sense of adventure, curiosity, a critical and questioning attitude, self-motivation and reflection, inventiveness and independence of mind that gives rise to creativity and innovation. Instead, South Africa had a system of education for Black people that encouraged passiveness, rote learning, obedience to authority and discouraged intellectual risk-taking, curiosity or independent thought. Further details on the historical background of the education system in South Africa are provided in Chapter 2

1.3 The need for transformation in the teaching of mathematics

The introduction of a new curriculum marked a change from content-based to outcomes-based education. The characteristics of the traditional curriculum in mathematics were identified as encouraging passive learners, being examination-driven, requiring rote learning, having a content-based syllabus broken down into subjects, being textbook-oriented and teacher-centred. The syllabus was seen as rigid and non-negotiable. The teacher was responsible for students' learning and providing motivation for learning but this was largely dependent on the personality of the teacher and a top-down curriculum development (Department of Education, 1997a; Nkabinde, 1997).

The traditional approaches, as documented, have not been helpful during the transformative period of introducing Curriculum 2005 to South African schools. The new curriculum strives to enable all learners to reach their maximum learning potential by focusing on learner-centred and activity-based approach (Department of Education, 1997a). The specific outcomes to be achieved in mathematics are provided in Table 2.3 in Chapter 2.

The President of South Africa, Mr. Thabo Mbeki, has unequivocally expressed a desire to transform the teaching of mathematics and science in the country. His view is captured in the preface of a draft intervention document entitled the National Strategy for Science, Mathematics and Technology Education (SMT):

> Special attention will need to be given to the compelling evidence that the country has a critical shortage of mathematics, science, and language teachers, and to the demands of new information and communication technologies (Department of Education, 2000a, p. 2).

At the centre of these educational reforms, since the inception of the democratic government in 1994, was the priority of the government to seek appropriate intervention mechanisms to address the educational imbalances inherited from the legacy of apartheid. Among the priority list to enact this transformation process was to raise the achievement levels at matriculation, especially in mathematics and science, and to upgrade the majority of unqualified and under-qualified teachers who are presently teaching mathematics in the schools, especially in township schools. Among these strategies, the National Department of Education prioritised improvement specifically in mathematics education through the National Strategy of Mathematics, Science Technology Education (Department of Education, 2001). More details of these endeavours are provided in Section 2.2.7 in Chapter 2.

1.4 The need for research-based intervention

The previous section discussed the need for transformation of mathematics teaching in South Africa and the different strategies at the onset of a democratic government in 1994 that are envisaged to improve the quality of mathematics teaching and learning. Currently, no research had been conducted to inform these interventions. Moreover, it has been acknowledged that there is little known about which models for teacher education work or why they work (Graven, 2002). Consequently, this section presents an argument for research-based intervention.

As mentioned earlier, one of my roles as a Research Assistant in the Faculty of Science at UNISA is to help gather baseline information that would inform the design of appropriate programmes for the professional development of mathematics, science and technology teachers. These teachers would be enrolled at the Centre for the Improvement of Mathematics, Science and Technology Education (CIMSTE) for this professional development. Working with the teachers would provide research-based data that could help address currently identified problems in mathematics, science and technology education (SMT).

To mark the importance of research to guide action, at the official launch of the establishment of CIMSTE at UNISA, Professor Diane Grayson, the Head of CIMSTE, stated:

> In South Africa, we have seen countless examples of educational interventions that have failed to achieve the intended goals or that have died early deaths. Not only have large sums of money been wasted in the process, but also many people involved have become disillusioned or demoralized as a result. Some of these tragedies might have been avoided if appropriate research had been carried out. Research is needed to identify what the problems and needs actually are, not just what we think they might be intuitively (reality is often counter-intuitive). Research is also needed to evaluate the effectiveness of various interventions, not only after everything has been cast in stone, but also early on in the process when modifications can still be made. (Grayson, 2003)

In 2000, the Department of Education drafted and made as policy the Norms and Standards for Educators that provided a basis to develop programmes and qualifications that would be recognised by the Department of Education for employment (See Section 2.1.6). According to this document, these Norms and Standards need to be informed by continuous research, thus acknowledging and legitimising the need for conducting research to inform policy (Department of Education, 2000b). Such a claim is supported by Pinto (2001) who stated that one of the most effective ways of evaluating practice, and improving it, is to do research.

In support of research-based information to help in-service workshops and service providers, Mtetwa, Ncube, Ndeya - Ndereya, and Engels (1998) argued that:

> ... such research-based information would provide [them] with clearer ideas for designing pragmatic in-service support systems in their regions and a starting point for thinking about and planning workshop activities in their science and maths centres. (p. 17)

Dr, Taole, the director of the National Research Foundation (NRF) of South Africa, in a call for a change in the existing research culture, remarked that at the advent of an outcomes-based education (OBE) system in South Africa, there is a need for OBE projects to rate high in defining the context within which a research agenda needs to be drawn up. Taole (2000) emphasised that this new research culture should be characterised by long-term studies that incorporate a full range of components of the education system, such as the learners, the educators, the community, the curriculum, the resources and must seek to understand the interplay amongst these components. There is also a call for increased research which explores different models of teacher education in order to examine which types of interventions succeed and why (Chisolm et al., 2000; Kahn, 2000). The needs for intervention in teacher education in South Africa, cited by Graven (2002), include increasing the low numbers of qualified mathematics teachers, the implementation of Curriculum 2005 and the lack of classroom based-research to inform practice.

Referring to in-service training in the context of curriculum change, Graven (2002) reported on evaluation studies that were conducted on some of the teacher education in-service projects at the senior phase (Grades 7-9) prior to the implementation of the new curriculum. Implementation at the senior-phase level began in1998. (Adler, 1995; Graven, 1997, 1998; Taylor & Vinjevold, 1999). Previous studies, according to Graven, did not produce rich qualitative data on the nature of teacher learning in relation to current change or the impact of intervention programs in schools. Thus, there is currently very little published research on mathematics teacher learning in relation to teachers making sense of the new curriculum in South Africa.

Kahn (2000) suggested that contextual factors must be central to research since what works in some schools (or countries) might not work in others. The implication is that it is important for research to be conducted within the context in which it will be applied. There are a wide range of contexts within the South African situation with its unique 'rainbow nation' — a term coined by Reverend Desmond Tutu — which implies a nation marked by a variety of cultures, languages, religions and ethnic groups (Cuthbertson, 1998). In line with the call to conduct research in different contexts, this study's research focus was in the context of township schools in Gauteng Province.

This study comes at a time when South Africa needs appropriate educational interventions that will address past imbalances. Having realised this need for research-based evidence, the greatest challenge is to use an instrument that is capable of identifying the *real* nature of classroom practices in a way that exposes the kind of teaching that teachers use. In so doing, the information obtained could direct professional development interventions designed to improve the current state of mathematics teaching, especially in township schools. To investigate the practices of mathematics teaching in township schools, the Secondary Teaching Analysis Matrix-Mathematics (STAM-Mathematics) (Gallagher & Parker, 1995) was used to analyse the teaching practices of eight teachers. STAM measures the teachers' content knowledge, teachers' actions and assessment, students' actions, availability of resources and the classroom environment.

1.5 The research problem and research questions

The research problem investigated in this study is the practices of mathematics teachers in township secondary schools in Gauteng, Pretoria.

The five research questions that guided the study are:

1) What is the status of the teachers' content knowledge?
2) What is the status of the teachers' teaching?
3) What is the status of the teachers' assessment practices?
4) What is the status of the interaction between the teachers and the students?
5) What is the status of the resource availability in the schools?

The study took place in three phases. Phase one was to observe the teachers' lessons in three schools. Phase two was to analyse the lessons using STAM and identify whether the teachers' teaching was didactic, transitional or conceptual. Phase three was to synthesise the predominant lesson features based on the results in phase two. The research approach in this study is from detailed field-notes of observations and videotape recordings of township secondary mathematics teachers' classroom practices.

1.6 Significance

The study is significant in the following ways:

This investigation will provide first hand information about the practices of mathematics teaching and learning in township schools that will help to decide appropriate ways of informing professional development efforts for reform in mathematics education in South Africa.

This study will provide a better understanding of what happens in the classrooms and schools because classroom practice has been analysed using STAM, a previously tested instrument, and the various descriptors have proven to be useful for categorising teaching. No study has been conducted in South Africa that used STAM to analyse teaching and the use of STAM in this study may lead to more research in assessing teaching in other disciplines.

With the introduction of Curriculum 2005, South Africa needs research that is based and rooted in real issues of the classroom. This study has provided such information. By identifying the current state of mathematics teaching in secondary schools in South Africa, this research will also serve as a gauge of how far the implementation of in-service programmes in schools is being successful. The study can be used as a tool to measure reforms since the election of the democratic government in 1994.

By adopting the framework of Gallagher and Parker (1995), the study will add literature in the use of STAM. This research gives an opportunity to popularise the instrument that may be adopted for use by researchers, pre-service and in-service teacher educators, policy makers, and practicing teachers themselves in South Africa and elsewhere.

Because of the comprehensiveness of STAM, this study should help teachers to be aware of the gaps and depths of their own knowledge of content and teaching practices. Furthermore, the use of the instrument can indicate how much teachers still need to improve their practice along the five dimensions provided by STAM, namely, content, teaching, assessment practices, teacher-student interactions and resources in order to change or improve their teaching from didactic to conceptual practice.

1.7 Limitations of the study

The limitations of the study that could impact on the outcomes of the investigation include the nature and size of the sample and the topics taught in the lessons. The presence of the researcher and video in the classroom could have influenced the learners' and the teachers' actions. The researcher's bias in terms of field-notes and personal reflections could limit authenticity. The disruption of data collection created a complexity whereby it impacted on the number of lessons that could have been observed. A further complication is that in some lessons very little information could be extracted for use in the lesson analysis. Although the reliability of analysis of teaching using STAM is greater when more than one person provides judgement (see Chapters 2 and 4), the analysis in this study was based upon the researcher's analysis and her supervisor's assessment of this analysis. This procedure was unavoidable given the inherent subjectivity that is characteristic of this interpretive research design. These limitations are attended to in the last chapter of the thesis.

1.8 Outline of the chapters

This chapter has provided the rationale for the study, with particular reference to the reflections of the author as a learner and teacher in South Africa, to provide the historical background to the Bantu Education system, the need for reform in the teaching of mathematics and the need for research-based information to guide teacher in-service programmes. The research problem and research questions are stated, and the significance and limitations of the study are identified. The scope of the study is captured in the following chapters.

Chapter 2: Literature review

With guidance from the research problem and questions in Chapter 1, a discussion of the writings and previous research that the study has drawn upon includes the historical background of the South African education system in the pre-and post-apartheid period to illustrate an understanding of the background in the teaching and learning of mathematics in township schools.

The various problems that affected mathematics teacher education as a consequence of Bantu Education are advanced and the current intervention programs in mathematics education in South Africa are discussed. The role of teacher knowledge and instruments for analysing teaching are provided and finally details for the specific instrument, the Secondary Teaching Analysis Matrix- Mathematics (STAM-Mathematics) used within this current study, as an alternative for examining teachers' practices is, described.

Chapter 3: Methodology

Chapter 3 contains an outline of the aspects of the research processes that have been followed to achieve the purpose of the study with particular reference to the sample selected, data collection procedures, and ethical issues. The research processes outlined has been drawn with guidance from Mamiala (2002). The school context, problems concerned with conducting research in South Africa and in township schools, the description of the framework of Gallagher and Parker (1995) that guided the analysis of the lesson observations are discussed.

Chapter 4: Results

Chapter 4 presents the findings of the analysed lessons relating to the main research problem. Detailed descriptions of the lessons observed followed by analysis of each lesson according to the 22 STAM descriptors and also the researchers' reflective notes are presented. A summary of the results of investigating the status of teaching and learning as characterised by the STAM is offered.

Chapter 5: Synthesis, Recommendations and Conclusions

Chapter 5 contains a synthesis of the results that have been analysed in Chapter 4. These are presented by synthesising the results in the form of addressing the research problem and the five research questions of the study. Recommendations for in-service of mathematics teaching in township schools are provided. The last sections deal with how the limitations were addressed, suggestions for further research and the summary of the thesis.

1.9 Conclusion

Chapter I introduced the study by giving an account of the reflections of the researcher as a learner and teacher of mathematics in South Africa as background to the former and current South African education system. The need for research-based information as a guide to professional development programmes in mathematics education was provided. The research problem and questions and the significance of the study were presented and the chapter concludes with the outline of the structure of the thesis and the limitations of the study.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter presents the literature review in the study of investigating the status of mathematics teaching and learning in township schools. Firstly, as background to the education system in South Africa, the period before democracy and after democracy is discussed and the various inherited problems that affected the quality of teacher training are advanced together with the intervention strategies by the National Department of Education to address the problems. Secondly, research studies on teacher knowledge and their relationship to performance are offered. Lastly, instruments used to analyse teaching are reviewed together with the historical development of STAM (Gallagher & Parker, 1995), the framework used in this study.

2.1 Historical Background to the South African Education System

2.1.1 Introduction

This section reports on the historical background to the educational provisions in South Africa in the pre-democratic era (before 1994) and the post-apartheid period (after 1994). The acts as discussed here illustrate legalisation of apartheid laws in South Africa of separation and inequity in terms of race, amenities, jobs, residential areas, educational opportunities and allocation of funds.

2.1.2 The pre-democratic period-before 1994

The Population Registration Act (No.30) of 1950 provided the basis for separating the population of South Africa into different races (Parsons, 1982). Under this act, all residents of South Africa were to be classified as White, Coloured, or Native (later called Bantu) and Indians. The Reservation of Separate Amenities Act (No.49) (Parsons, 1982) of 1953 brought into legislation the concept of segregation on general facilities, education, and jobs. This act stated that all races should have separate amenities—such as toilets, parks, and beaches—and that these needed not be of an equivalent quality. The Industrial Conciliation Act (No.28) (Parsons, 1982) of 1956 enabled the Minister of Labour to reserve categories of work for members of specified racial groups. If the minister felt that White workers were being pressurized by unfair competition from Blacks, he could re-categorise jobs for Whites only and increase their rates of pay. The Group Areas Act (No. 41) (Parsons, 1982) of 1950 provided laws for geographic, social and political separation. These laws divided South Africa into separate areas for Whites and Blacks (Parsons, 1982). There were ten homelands or Bantustands in which Africans were residing according to their different ethnicities (Battersby, 1994), namely Pedi, Venda, Tsonga, Zulu, Xhosa, Tswana, Swazi, Sotho, Ndebele. The government was given power to forcibly remove people from areas not designated for their particular racial group.

Townships

The following discussion on townships is given to provide background on the type of culture that prevailed in the townships which are a focus of this study.

Townships originated as semi-urban dwellings where the workers in urban areas were residing. People living in townships were *originally* mostly unskilled Black workers generally from the different homelands who provided labour in the cities, doing menial labour such as mining, construction and domestic work. The outskirts of townships are generally marked by tremendous endless shacks/shanties (euphemistically called informal housing); these shanties are generally areas that are marked by high unemployment and crime rates. Children from these areas attended school in the townships which generally have good structures of buildings that are occasionally marked by signs of vandalism. Townships were the sites of violent political struggle during the apartheid era, the remnants of which are still present to date (Nkabinde, 1997). The data used in this study were collected in one of these townships on the outskirts of Pretoria.

Violence eruption in 1976

Tension over language in education erupted into violence on June 16, 1976 when students took it to the streets in Soweto, a township in Johannesburg. This protest was prompted by a decision that was made by the Prime Minister Verwoerd, who was the architect of the Bantu Education system, to enforce a regulation requiring that half of all high school subjects be taught in Afrikaans (Nkabinde, 1997). The harsh response of the police to this march, led to deaths of several children, some as young as eight years. It was at this time that the African National Congress youth supporters abandoned school and some people left the country. The protests then were aimed at making South Africa ungovernable.

As a result of the 1976 unrest, schools, especially township schools, suffered damage as vandals and arsonists destroyed schools and school property. Students who tried to attend school and their teachers were sometimes attacked. It was difficult to have normal schooling and education, especially among the Black communities, almost came to a halt (Nkabinde, 1997).

2.1.3 Bantu education

The Bantu Education Act (No.47) of 1953 brought about a legislative implementation of apartheid that was aimed at separating educational opportunities for different racial groups namely, Whites, Blacks, Coloureds and Indians in South Africa. This legislation decreed that Blacks were to be provided with separate educational facilities under the control of the Department of Native Affairs, rather that the Department of Education. The word "Bantu" in the Nguni group of languages such as Zulu, Xhosa, Ndebele, and others means "people" (Arnold, 1981; Nkabinde, 1997). Africans usually use the word "aBantu" or "batho" to refer to people or the human race. In the former South African government, the term Bantu was selected as an official term to refer to Blacks. Hence, the term "Bantu Education" was a low quality inferior separate education designed for Black Africans only (Nkabinde, 1997). Hendriek Verwoerd, the then Minister of Native Affairs, said:

> I will reform it [Bantu education] so that Natives will be taught from childhood to realize that equality with Europeans is not for them (Parsons, 1982, p. 291).
>
> What is the use of teaching a Bantu child mathematics when he cannot use it in practice? (Parsons, 1982, p. 292).

According to Minister Verwoerd, Bantu children in these schools would be trained in accordance with their opportunities in life which he considered did not reach above the level of certain forms of labour (Parsons, 1982).

Minister Verwoerd attacked the liberalism of missionary education, which gave Black children ideas of growing up to live in a world of equal rights between Black and White. This 1953 act also removed state subsidies from denominational/missionary schools with the result that most of the mission-run African institutions, for example, Kilnerton and Emmerentia Geldenhuis, which were very good schools, were sold to the government or closed (Nkabinde, 1997). There were some exceptions made to those closures that included schools run by the Roman Catholic Church and the Seventh Day Adventists. The extension of the University Education Act (No. 45) prohibited Blacks from attending White institutions, though there were a few exceptions. Also there were separate universities and colleges for Africans, Coloured, and Indians (Nkabinde, 1997; Parsons, 1982).

The aim of Bantu Education was to make Black school graduates incapable of competing on equal terms with their White counterparts. The consequences of this deliberate inequality was a high illiteracy rate, overcrowded and poorly maintained classrooms, high-learner teacher ratios, high failure rates, insufficient funding, and low teacher morale among the Black population (Nkabinde, 1997). In addition, there was poor quality of primary education, outdated concepts with respect to technical education; low status of technical skills, a shortage of qualified mathematics, science and technical teachers, as well as a lack of equipment and overcrowded classrooms (Lesage, 1994).

Secondary level curricula

The syllabus for the secondary level of education emphasised examinations and certificates which encouraged rote learning at the expense of stimulating critical thinking and analysis. Students were never encouraged to acquire knowledge, skills, and attitudes through participation. Science subjects were not taught in schools where there was a shortage of teachers (Baine & Mwamwenda, 1994). Secondary education in South Africa was described as authoritarian, disciplinarian, teacher-dominated, content-oriented, and knowledge-based (Baine & Mwamwenda, 1994). Usually teachers relied heavily on prescribed and recommended books; class notes were dictated; memorization was the order of the day; students were never permitted to discuss and share their views. Interaction was rare and active participation and projects involving hands-on activities did not occur (Baine & Mwamwenda, 1994). This curriculum in Black schools led to memorisation and cramming for examinations rather than comprehension and application of knowledge and skills (Baine & Mwamwenda, 1994; Nkabinde, 1997).

Examinations

External examinations in Black schools were established centrally and controlled by the Department of Education and Training. Unlike their other racial counterparts, Black learners wrote three major external examinations (Behr, 1978). These examinations, written at the end of primary school level, at the end of junior high school and at the end of matriculation, limited the number of Black learners who entered the next level and consequently the job market. As a result, very few Africans completed high school. The pass rates were always lower than other racial groups as seen in Table 2.1.

Table 2.1 Matriculation results by race

Year	Group			
	Africans	Coloureds	Indians	Whites
1987	50.0 %	66.0 %	86.0 %	90.0 %
1989	42.0 %	72.7 %	93.6 %	96.9 %
1993	38.3 %	86.0 %	93.0 %	98.0 %

Some reasons for poor performance in African schools

There are varied reasons to explain the poor performance described in Table 2.1. A primary cause was the emphasis on examinations that resulted in teachers' obsession with preparing students for certificates and not for the development of general ability for independent thinking and judgement (Nkabinde, 1997).

Some of the reasons why Black students performed poorly on external examinations mentioned by Donald (1995) were school-related factors such as the language of instruction, lack of facilities, poor teaching, poor handling of examinations papers, over crowdedness, and school disruptions. Personal factors included lack of motivation, poor study skills, and intellectual limitations, as well as existing emotional and physiological problems. Family factors included poverty, lack of parental support, and too many domestic demands among African students. The lack of facilities and equipment such as teaching materials including textbooks, libraries, electricity, computers, laboratories, and scientific apparatus has been well documented as contributing factors to poor performance in schools (Arnott & Kubeka, 1997; Nkabinde, 1997; Simon, 1991; Slammert, 1991). Furthermore, poor training of teachers contributed to the academic failure of many Black students and this was especially so in the natural sciences, for which the majority of African teachers teaching these subjects had no formal training (Kachelholffer, 1995). Overall, teachers in the township schools were marginalised by the legislative implementation through the acts as discussed and were trained under Bantu education.

2.1.4. Quality and training teachers in South Africa

Well-trained teachers are a central component in the educational process. Unfortunately, large numbers of teachers currently teaching mathematics in secondary schools in South Africa are unqualified or under qualified (Arnott & Kubeka, 1997). A teacher is considered to be unqualified if s (he) has had no formal teacher training qualification. On the other hand, a teacher is deemed to be under-qualified if s (he) has three or less years of teacher training (Bansilal, 2002).

Baine and Mwamwenda (1994) reported in 1988 that 17 percent of South African primary school teachers in Black schools outside the homelands and 29 percent in the non-independent homelands were not qualified. It was further observed by Baine and Mwamwenda that in the then Transkei (Xhosa homeland), approximately 51 percent of the teachers in the senior secondary schools and 63 percent of the teachers in the junior secondary schools were given roles beyond their qualifications, even though a majority had been qualified to teach at lower levels. These teachers were not qualified to teach at the secondary level, and they were not qualified to teach specialized subjects such as mathematics, science, and technical skills (Baine & Mwamwenda, 1994). Moreover, Nkabinde (1997) put forward the argument that little focus had been directed to improve Black teacher training. This problem of teacher training in South Africa has been complicated by an education system of separateness under apartheid, unequal funding and with the least amount of money being allocated to Blacks. In addition, the teacher education curriculum was determined by the Department of Education and Training. They determined how and what was to be taught at these colleges.

Arnott and Kubeka (1997), in a report that was mandated by the Department of Education to provide information about mathematics and science teacher training in South Africa, highlighted the variations in the quality and training of mathematics and science teaching at colleges of education. The report revealed a lack of importance given to mathematics and physical science curriculum, which they saw as an outcome of Bantu Education that did not emphasise the need for learners' understanding of concepts. This lack of emphasis exacerbated the problems of how mathematics and physical science was perceived in the curricula for teacher education.

The report of Arnott and Kubeka (1997) also revealed that schools and colleges of education were being under-resourced both in terms of teachers and laboratories, equipment, textbooks and libraries. Further, because of the lack of links with universities, this resulted in the continued isolation of the African Black teacher education sector from the latest developments in mathematics education. The effect was a lack of understanding on the side of college lecturers and teachers and also of the relevance of these subjects to daily life and the environment. In addition, this isolation of college lecturers caused lecturers not to be exposed to new developments in didactics. Consequently, teacher-centred approaches became entrenched and accepted as the norm at colleges of education and no research was done.

Further, a lack of academic background of the educators caused them to have a passive dependence on whatever the higher educational authorities decided, leading to an unquestioning, uncritical attitude to relevant curriculum development for teacher education (Arnott & Kubeka, 1997). The report also revealed that although colleges of education made students aware of the different teaching methodologies, the lecturers rarely seemed to employ these methods themselves and were therefore not the role models that they should be. Examination questions were reported to be stereotyped.

It was also reported that English as a second language often presented problems in the understanding and communicating of certain concepts in mathematics and physical science and students' language development was minimal. Arnott and Kubeka (1997) reported with certainty that there was little evidence that lecturers were familiar with the concept of language and cognition across curriculum.

The lecturer's low morale was a result of continuing student disruptions that caused little work to be done in teacher education. It was also reported that at several colleges of education, most of the lecturers themselves had little or no experience of teaching in schools and hence the lecturers were not in a position to provide good role models for their student teachers. This lack of school experience also had implications for the teaching of methodology where there is a noticeable division between theory and practice. The lecturers' report in their findings revealed that the quality of students was poor and commented that students rarely participated in lectures, and that there seemed to be little commitment to teaching as a career by the students (Arnott & Kubeka, 1997).

Training of Black teachers

The training of Black teachers is still perceived to be inferior to that of other races. For example, Kachelhoffer (1995) explained that the majority of Black teachers are trained according to a three-year curriculum at teachers' colleges for primary and secondary education. Approximately 45% of Black teachers have less than three years of training after matriculation. On the other hand, their White counterparts are trained at teachers' colleges for primary education and at universities for secondary education over a four-year period. This poor quality training of Black teachers not only affected the quality of instruction received by the students, but also prevented the teachers from intellectual curiosity that made teaching enjoyable and learning self-rewarding for students.

Black teachers at all levels of education according to Nkabinde (1997) have been operating with a top-down, centrally prescribed syllabus that has been inappropriate and largely irrelevant to the practical needs of the Black communities (Gray, 1995). Prior to 1996, Black training colleges generally were staffed by poorly trained teachers who were the products of Bantu education (Arnott & Kubeka, 1997; Gray, 1995).

Primary school teacher training

The first certificate introduced for Black South Africans was two years of teacher training for candidates with Standard Six Certificate to obtain the Lower Primary Teacher Certificate (LPTC) and two years after Standard Eight to qualify for the Primary Teachers Certificate (PTC). Later, training was over three years to obtain a Junior Primary School Diploma (JPTD) and a Senior Primary Diploma (SPTD) (Kachelholffer, 1995; Ngoepe, 1998b; Nkabinde, 1997).

Secondary teacher training

In order to teach at a secondary or high school level, the Junior Secondary Teacher Diploma required a matriculation certificate and the training took two years. Later, training was over a period of three years and the qualification received was a Secondary Teachers Diploma (STD) (Kachelholffer, 1995). Universities offered a one-year certificate after a degree that was referred to as University Education Diploma (UED) or a two-year certificate Higher Education Diploma (HED).

Technical training

Teachers teaching in technical colleges typically hold a technical qualification with a mathematics component. Joubert (1992) mentioned that teachers at technical colleges very seldom received training prior to actually practising the profession. This had adverse effects on the quality of teaching.

Teacher qualifications

In South Africa, very few teachers are university educated because most pre-service students attended colleges of education (Department of Education, 2001). A 1998 survey of colleges of education and training revealed that 63.3% of students were registered for Junior Primary (Grade 1-4) and Senior Primary (Grade 5-7) qualifications while only 32.7% were registered for a secondary qualification. This situation is also exacerbated by the fact that in eight of the nine South African provinces the required qualification value (REQV) is 13, that is, Grade 12 plus three years training. Because of this REQV, teachers would consider themselves qualified to teach. Due to a high shortage of qualified mathematics teachers, those holding a professional certificate for primary school teaching are required to teach secondary school mathematics.

The methods of training

Many African teachers are unable to use innovative methods of teaching partly because of their educational experience at teacher colleges. Walker (1992) provided evidence that the training in colleges of education was dominated by transmission teaching, which affected the creativity, motivation, and the effective use of talents of the teachers. Consequently, many Black teachers cannot devise teaching aids and materials to fit the conditions found in the schools but rely heavily on prescribed textbooks. Teachers lacked models of quality practice. To expect Black teachers to produce curious, analytic learners unless they are teachers of the first rank is not fair (Walker, 1992).

Donald and Hlongwane (1989) noted that in most Black schools, the teaching process emphasised chalk and talk methods, which leads to reliance on rote learning. Subsequently Black schools neglected the development of students' mental abilities, promotion of reasoning and problem-solving powers, or creative imagination. In most instances, Black teachers are ill prepared for the actual problems that confront them in their classrooms because they received little or no support from education authorities. Teachers tended to comply with what was prescribed in the syllabus.

Nkabinde (1997) alleges that Black teachers adopted the teaching methods from their training in their classrooms. Most Black teachers have never developed a critical awareness of the world (Christie, 1985) so they are unlikely to instil the same values in their learners. Because of the limited frame of reference, Black teachers do not know what they can or cannot do to change their circumstances. The result is an education that has no purpose or direction, which Christie referred to as education for domestication.

This section has shown that instruction in Black colleges of teacher training was authoritarian and that teaching methods involved rote learning and amassing of information that hindered creativity and imagination on the part of students. This kind of training is likely to be modelled by teachers after completion of their training. Poorly qualified educators are likely to result in low-level student output that in turn results in fewer competent trainee teachers entering the system.

2.1.5 Impact of teacher training on teachers

Professional morale

Lack of support from other peers with regard to team teaching strategies and curriculum thinking also contributed to poor teaching methods. Black teachers typically work in academic isolation even within the same school (Gray, 1995), a situation compounded by the fact that only in rare circumstances do several teachers in the same school teach the same subject. Staff meetings in general address administrative or extracurricular concerns other than professional issues such as teachers' professionalism, concerns of professional qualifications and higher professional status. Generally, African teachers' status and prestige are low because of their poor working conditions and poor qualifications (Nkabinde, 1997).

Lack of motivation

According to Nxumalo (1990), many teachers chose the teaching profession for several reasons, among which are because the teaching program appeared to be less demanding than what was available for the students at that given time. Also it was cheaper to pursue teacher education than other diplomas and parents attached more status to teaching than to other professions. In other situations, teaching was chosen because the student had failed to attain promotional grades to degrees or diplomas that had been chosen at the beginning.

Unprofessionalism

The lack of professional morale and motivation might have resulted in unprofessionalism that has been found to be highly prevalent among South African teachers. For example, in a survey on professional attitudes of mathematics and science teachers carried out in all the nine provinces of South Africa using a sample of 1124, incidences of late coming, lack of preparation, general irresponsibility, lack of motivation and lack of commitment by teachers was reported (Grayson & Ngoepe, 2003; Grayson, Ono, Ngoepe, & Masakazu, 2001)

Low matriculation pass rate

The reasons that are attributed to the poor performance at matriculation are many, including poor tuition and guidance given by the many unqualified, underqualified and inexperienced teachers (Webb, 1998). Fortunately, these problems of poor performance in South African schools have been widely documented (Arnott & Kubeka, 1997; Graven, 2002; Howie & Plomp, 2002; Nkabinde, 1997) and researchers can start to address these problems. However, there has been a steady decrease in the number of mathematics Senior Certificate enrolments in the Higher Grade (HG) in the four years 1997-2000; for example, Higher Grade (HG) — 1997 (68 500), 1998 (60 300), 1999 (50 100) and 2000 (38 500). However, at Standard Grade (SG) during the same years — 1997 (184 200), 1998 (219 400), 1999 (231 200) and 2000 (254 500) show relatively increased numbers (Department of Education, 2001; Pinto, 2001). Table 2-2 indicates the low pass rate of African students in the different Provinces. The figure shows that there is a need to deal with this high failure rate and there is also a need for intervention strategies at various levels.

2.1.6 The post apartheid period after 1994

The first democratic election in South Africa in 1994 marked the beginning of a new democratic government that lay to rest the apartheid laws. Educational reform was at the centre of the new government, which had a great task, and made a priority of dismantling the inherited educational inequalities of Bantu Education. A system of education was to be established that builds on democracy, values of human dignity, equality, human rights and freedom, non-racism and non-sexism and provides access to a basic education for all through the provision that 'everyone has the right to basic education including adult education' (Department of Education, 1996b, 2001). The second challenge of the new democracy was to put in place an education system of lifelong learning so that South Africa could best meet the economic and global challenges of the 21st century; this was to be achieved by the introduction of curriculum 2005 (Department of Education, 2001).

Table 2.2 The numbers of African candidates by Province who wrote and passed Grade 12 mathematics

Province	Maths Higher Grade		Maths Standard Grade	
	Wrote	Wrote	Wrote	Pass
Western Cape	78	21	3889	662
Free State	471	115	12066	2454
Eastern Cape	362	113	36736	11101
Kwazulu-Natal	5772	746	40367	10309
Mpumalanga	1381	159	16451	3235
Northern	7780	1041	36884	5683
Gauteng	812	329	20497	5478
NorthWest	3575	595	12644	2200
Northern Cape	12	9	671	218
TOTALS	20243	3128	180202	41540

(Department of Education, 2001, p. 12)

The five key areas of transformation were as follows: Firstly, the apartheid structures were dismantled by establishing one national and nine provincial education departments. Organisationally, this meant integrating formerly divided bureaucracies and transferring institutions, staff, offices, assets, learners and teachers into a new system. Secondly, a financial model of education was established that entailed moving away from racial inequality and reorienting towards one budget allocation on the basis of racial equity through funds available from the Reconstruction and Development Programme. Thirdly, education was transformed by creating various legislative policies such as the National Education Policy Act (NEPA) (1996a), the South African Schools Act (SASA) (1996c), and the South African Qualifications Authority (SAQA) (1995). Fourthly, government expenditure on education was increased and education expenditure restructured. Lastly, colleges of eduction were incorporated into the Higher Education sector and norms and standards were developed for teacher education. This responsibility was given to the Committee of Teacher Education Policy (COTEP). Various strategies were put in place, some of which included Tirisano, a Sotho name meaning 'working together'. Also, the Batho-Pele Strategy (meaning people first) was aimed at improving service delivery and accountability by establishing clear targets and performance indicators. (Department of Education, 2000a)

To mark this national priority, the Minister of Education, Professor Kader Asmal, in his 'Call for Action' said:

> The Ministry of Education will give top priority to the development and implementation of a long-range plan for teacher development, both pre-service and in-service, in support of outcomes based education and improved standards of teaching. (Department of Education, 2000a, p. 11).

This call for improvement in school mathematics has subsequently been articulated in diverse quarters, including the Council on Higher Education, The National Science and Technology Forum, The Mathematics Education Community, many mathematics educators' forums (Department of Education, 2000a).

One of the key foundation stones in the transformation of teaching in South African schools was the release of the Norms and Standards for educators as mentioned earlier (Department of Education, 2000b). Specifically, the Norms and Standards for education give descriptions of teachers' roles, their associated set of applied competencies (norms) and qualifications (standards) for the development of educators. These competencies and qualifications provide directions and guidelines for the pre-service and in-service development of professional and competent educators (they are used as a hallmark of what is regarded as a competent teacher).

Emphasis of the policy is on performance in schools, classrooms, management and support services of the schooling system.

According to the Department of Education (2000b), applied competencies is the overarching term for three interconnected kinds of competence. Firstly, practical competence is the demonstrated ability in an authentic context to consider a range of possibilities for action, to make considered decisions about which possibility to follow and to perform the chosen action. Secondly, foundational competence is where a learner demonstrates an understanding of the knowledge and thinking that underpins the action taken. Thirdly, reflective competence entails demonstrating the ability to integrate or connect performances and decision-making with understanding. Reflective competence also includes an ability to adapt to change and unforeseen circumstances and to explain the reasons behind these adaptations.

In addition, applied competency refers to the ability of the teacher to integrate these competences, which constitute each of the seven educator roles outlined by the Department of Education (2000b) and which are perceived as important and need to be adopted in the new education system. These seven roles are learning mediator, interpreter and design of learning programmes and materials, leader, administrator and manager, scholar, researcher and lifelong learner, community, citizenship and pastoral role, assessor, and learning area subject, discipline and phase specialist (Department of Education, 2000b). According to Essop (2000), these standards for educators put strong emphasis on the importance of teachers' subject content knowledge which research has shown to be a *major weakness* of South African teachers. These standards mark a shift away from the authoritarian and rote-learning legacy of apartheid education and offer the promise of a new kind of educator for South African schools.

With regards to the changed nature and content of mathematics, mathematics is defined as a human activity and should empower learners to understand the contested nature of mathematical knowledge (National Department of Education, 1997). There is a shift from reproducing and mastering abstract mathematical skills and algorithms to constructing mathematical meaning in order to understand the world and make use of that understanding. Table 2.3 displays the specific outcomes that need to be achieved in mathematics as given by the Department of Education. Specific outcomes 3, 4 and 8 indicate a clear move away from the absolutist view of mathematics.

Table 2.3. The specific outcomes in mathematics as given by National Department of Education (1997)

1)	Demonstrate understanding about ways of working with numbers
2)	Manipulate number patterns in different ways
3)	Demonstrate the historical development of mathematics in various social and cultural contexts
4)	Critically analyse how mathematical relationships are used in social, political and economic relations
5)	Measure with competence and confidence in a variety of ways
6)	Use data from various contexts to make informed judgements
7)	Describe and represent express with shape, space, time and motion, using all available senses
8)	Analyse natural forms, cultural products and processes as representations of shape, space and time
9)	Use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes
10)	Use various logical processes to formulate, test and justify conjectures

Although legal apartheid is abolished, black African working class and poor people still suffer its legacy of poverty, dilapidated schools, landlessness, and unemployment as confirmed by the 1999 report of the Minister of Education:

> ...while the systemic changes brought about in the first five years provide a progressive and durable basis for improvements in the quality of learning, transformed learning opportunities were not yet accessible to the majority of poor people. Inequality is still writ large in the education system, and too many families are on the receiving end of unacceptably low standards of educational delivery. (Department of Education, 1999)

All these changes place new demands on the mathematics teachers, especially in township schools, several of which are investigated in the present study. The next section highlights some intervention programmes.

2.1.7 Current intervention programmes in South Africa

Intervention programmes in South Africa are undertaken by both local and outside agencies in the form of in-service training of teachers in response to the poor performance and retention rates associated with physical science and mathematics matriculations in the disadvantaged sectors of South Africa (Austin et al., 2002).

The Ripple programme was an intervention run in selected township schools with the aim of improving pass rates and raising the overall performance of both 'leader learners' and their peers in mathematics and science and also identifying factors which were perceived as contributing to success or failure during the programme (Webb, 1998). The nature of the programme was such that a selection of leader learners in science and mathematics was achieved. These learners were taught on weekends and learnt how to 'ripple' what they have learned to ten assigned 'peers' during the following week, under supervision by teachers and principals. The result of this intervention was a significant improvement in pass rates in Mathematics at Grade 12 up to the average of 16.8%. The most important factor perceived to determine the success rate was the selection of the teachers and leader learners (Webb, 1998).

Rogan, Grayson, van den Akker, Ndlalane and Aldous (2002) developed what they called a theory of implementation for developing countries that was designed to find out the extent to which the support given by service providers led to the implementation of the curriculum. Rogan et al. (2002) described a model that involved three constructs: profile of implementation, capacity to innovate, and outside support that examined the implementation of Curriculum 2005 (C2005) in the North West Province, Mpumalanga Secondary Science Initiative (MSSI) project. The capacity of the schools to innovate at the classroom level was influenced by the physical resources such as what was in the classroom and aspects of the school ecology such as whether classes took place. With regards to influences from outside the school, the findings revealed that the support that teachers received from the MSSI project workshops enabled the teachers to implement C2005.

Other studies by Johnson, Scholtz, Hodges, & Botha (2002) involved the use of curriculum materials introduced to science teachers in the Western Cape that aimed at developing learners' science process skills. The intervention of King (2002) involved introducing hands-on and learner-centred activities as well as the use of various teaching strategies, such as opportunities for individual work and discussion in groups. Examples of activities given were sorting, grouping, drawing, forming new shapes and making accurate constructions using mathematical instruments and making geometric constructions using a pair of compasses and protractor.

Some recent interventions involved various support programmes run at district levels in township schools that included the Secondary School's Intervention Programme (SSIP) for Mathematics, Physical Science, English, Biology and Accounting. This SSIP was intended for schools in previously disadvantaged areas such as townships with a pass rate of less than 60% in the mentioned subjects. Classes by qualified tutors conducted on Saturdays and during holidays concentrated on more difficult sections of the syllabus and examination preparation. Similarly, The Role Model Intervention Programme (RIMIP) exposed learners with potential to excellent enrichment programmes on Saturdays and during school holidays. A special programme intended for girl learners called Intombe promoted opportunities for girls to develop and improve their knowledge, skills and values in Mathematics and in Physical Science. These girls also were exposed to possible future careers in the field of Mathematics and Physical Science (Department of Education, 2003).

The National Strategy for Mathematics, Science and Technology Education (Department of Education, 2001) came as a national intervention strategy that focused on three issues: Firstly, to raise the participation and performance of historically disadvantaged learners in Senior Certificate science and mathematics; Secondly, to provide high-quality science, mathematics and technology education to all learners taking the first Further Education and Training Certificate (FETC) and General Education and Training Certificate (GETC); and lastly to increase and improve human resource capacity to deliver quality science, mathematics and technology education. However, the primary purpose of this strategy was to serve a short-term to medium programme of action to address the present problem of mathematics, science and technology education (Department of Education, 2001).

However, none of these intervention programmes discussed have been informed by research conducted in township teachers' classrooms prior to these interventions. Rather these programmes were based on the aspirations of the researchers, government or financial providers. In the next section writings about some teaching practices in South African classrooms are dwelt upon.

2.1.8 Teaching practices in South African schools

Despite the many initiatives led by the new South African government's post democracy elections, the problem of changing classroom practice from didactic to transformative forms is still a big issue. Jita (2002) acknowledged the fact that there are policy initiatives to improve mathematics and science education in South Africa but "the challenge has been that of finding ways to shift classroom practices from modal [i.e. traditional] to transformative forms" (Jita, 2002, p. 10).

Jita cited several studies confirming that the practices of many science and mathematics teachers, especially in Black schools, are characterised by modal and highly didactic teaching (Human Sciences Research Council (HSRC), 1981; Nduna-Watson, 1994). The classroom practices of most Black mathematics and science teachers are shaped by at least three related features, namely the syllabi, the textbook, and the national examinations. The lack of relevance to both the students' and the teachers' life experiences of the syllabi was acknowledged. Teaching in most mathematics and science classrooms in Black schools in South Africa prioritised factual knowledge, disregarding student experiences, and focused too much on tests and quizzes for examination preparation (Jita, 2002).

Jita cited similar studies by Macdonald and Rogan (1988) who identified a number of didactic teaching approaches that were common in many Black mathematics and science classrooms in South Africa. Such activities were listed as "teachers state the facts", "tells the students", and "corrects" while students' activities were characterised by "listen(ing)", "watch(ing)," "copy(ing)" notes," and "answering exercises"(Jita, 2002, p. 11).

Similarly, Ottervanger (2002) reported sub-Saharan classroom practices that were similar to South African mathematics and science classrooms which were recognised by the following characteristics: students are passive throughout the lesson; 'chalk and talk' is the preferred teaching style; there is an emphasis on factual knowledge; questions require only single words as answers, often provided in chorus; students do not ask questions; only correct answers are acknowledged; very little practical work is carried out. All the sub-Saharan countries mentioned are developing and are not unlike the situation in Black classrooms in South Africa.

Haberman (1991) uses the term "pedagogy of poverty" to refer to some of these constraints facing urban mathematics and science teachers in America. These constraints include large class sizes, inadequate preparation time, lower levels of training, inadequate classroom space, and outdated materials. The pedagogy in these classes was characterised by teacher-controlled activities such as giving information, tests, directions, and grades; monitoring seatwork; settling disputes; and reviewing tests and homework. Haberman (1991) and others suggested that it was unlikely that most urban mathematics and science students were experiencing opportunities for scientific/mathematical inquiry in their classrooms and therefore were not being allowed the opportunities to develop foundational thinking skills for scientific/mathematical literacy. The constraints similar to those reported are prevalent in township schools where this study was conducted.

Even though the above practices were identified as prevalent in mathematics and science classrooms, so far, studies that suggested how transformation of these practices should take place have not been reported.

2.1.9 Code switching

As mentioned earlier, the South African population is comprised of different ethnic groups and code switching between two or more languages is common in South African classrooms (Setati, 1998). Code switching is perceived as a language practice that teachers have been using to cope with teaching mathematics in English to learners whose first language is not English. Setati (1998) alleged that code switching is regarded by some people as a grammarless mixture of languages. Studies on code switching revealed that it is used for various reasons, for example, in a bi/multilingual mathematics interaction, when the teacher or a learner ran out of English parallel mathematical terms (Setati, 1998) or to enable both learner-learner and learner–teacher interactions to take place (Ncedo, Peires, & Morar, 2002).

Code switching has been identified as one of the dilemmas of teaching and learning mathematics in multilingual classrooms (Adler, 1998) where the main language of the teacher and learners is different from the Language of Learning and Teaching (LoLT). Adler observed that there are ongoing dilemmas for the teacher as to whether or not to switch between the LoLT and the learners' main language or whether or not to encourage learners to use their main language(s) in group discussions or whole-class discussion. According to Adler, these dilemmas are seen as a result of the learners' need to access the LoLT because examinations occur in this language. This study of Adler suggests that the dilemmas of code switching in multilingual mathematics classrooms cannot necessarily be resolved, but they do however have to be managed.

Recently, In South Africa, the language-in–education policy of 1997 recognises 11 official languages and is supportive of code switching as a resource for learners and teachers in multilingual classrooms. In addition to English and Afrikaans, the nine African languages are, Sesotho, Sepedi, Setswana, Tshivenda, Xitsonga, Isindebele, IsiXhosa, IsiSwati and IsiZulu (Department of Education, 1997b). But this is an issue that still needs further clarification or research because these African languages are yet to be developed for academic use.

2.1.10 Interactions

Research into teacher questions in mathematics and science classrooms revealed a consistent correlation between the frequency of teachers' questions and learners' actions (Kandjeo-Marenga et al., 2003). The frequency and the nature of the questions posed in class are typically related to the teacher's knowledge of the subject matter. When teaching topics on which they have weak subject-matter knowledge, teachers tend to talk for long periods and ask most questions at a low cognitive level aimed at controlling the classroom conversation (Carlsen, 1993). In contrast, when teachers deal with a topic on which they have good subject knowledge, there is high student participation and few questions but those questions, as Carlsen observed, have a more varied cognitive demand. Another study in senior secondary mathematics and science classrooms in Namibia, which investigated the nature and frequency of teacher-generated questions, showed that the majority of teachers' questions were closed and were also at a low cognitive level (Kandjeo-Marenga et al., 2003). Lessons dominated by teacher talk and low-level questioning in South African classrooms have been reported (Taylor & Vinjevold, 1999).

2.2 Research studies on teacher knowledge in mathematics

2.2.1 Introduction

The introductory section of this chapter showed how apartheid laws were legitimised to deliberately under prepare Black teachers to teach by offering them Bantu Education. The research reviewed in this section reveals issues related to mathematics teachers' knowledge.

2.2.2 Studies in South Africa

The President's Educative Initiative report was a result of a research project done by Taylor and Vinjevold (1999) to investigate what was happening in the mathematics and English classrooms in South Africa. One of the major findings of the study concerned *low level conceptual knowledge* of the teachers:

> The most unequivocal finding about teachers is that a poor grasp on the part of teachers of the fundamental concepts in the knowledge areas they are responsible for is a major problem in disadvantaged classrooms. (Taylor & Vinjevold, 1999, p. 159)

Another study on teacher knowledge concerned 156 underqualified teachers from the Eastern Cape (one of South Africa's nine provinces) by Glover and King (2000) who found that many of the teachers held misconceptions in algebra similar to those exhibited by school students in other countries described by Kieran (1992), Perso (1993) and Booth (1995).

Another study by Stols (2003) investigated the influence of South African rural teachers' knowledge on their learners' knowledge. The teachers and learners were given the same mathematics examination questions that were categorised at different cognitive levels using Bloom's Taxonomy set at knowledge and skills, understanding and application and creative thought. The Pearson correlation coefficient between the teachers' and the learners' ability in the test was high, namely 0.80, thus confirming the existence of a strong relationship between the teacher and the learner's mathematical knowledge and also suggesting the need to improve the teachers' knowledge.

Mji (1998) cited a study conducted by Oliver and Glenross (1995) to evaluate teaching techniques used in Transkei, South Africa to assess teachers' competencies in primary mathematics. These teachers lacked a range of teaching techniques necessary for assisting learners to develop problem-solving skills and these teachers were reluctant to move away from the textbook.

2.2.3 Studies conducted elsewhere

The teacher's content knowledge can make a great contribution to student's content knowledge and understanding of subject matter. This relationship between students' understanding and teacher's content knowledge was also emphasised by Prawat (1989) in his research:

> ...[There is] a growing body of research relating teachers' subject matter understanding to students' subject matter understanding. Until recently, this kind of research was virtually nonexistent (Shulman, 1986) ... the recent emphasis on conceptual understanding and higher order thinking in students, particularly in mathematics, ...the role of teacher content knowledge is being re-examined. This research is demonstrating that there is a clear relationship between what teachers know about content and the *depth* (my italics) of understanding they are able to promote in students. This relationship is far

> from perfect; other variables influence the extent to which teachers utilize their content knowledge. (Prawat, 1989, p. 319)

In citing a study of two teachers teaching a topic outside their field of expertise, Fraser and Tobin (1990) highlighted the difficulty faced by the teachers in diagnosing student misconceptions and helping students to develop scientific conceptions. These authors further pointed out that errors in the content presented by teachers could result in student misunderstanding. Moreover, these misconceptions might be difficult to change (Treagust, Duit, & Fraser, 1996) because of the faith that students have in the validity of knowledge provided by a dynamic, forceful and confident teacher. This and the previously cited studies indicate that the impact of teachers' knowledge, especially at low levels, can result in student misconceptions.

2.2.4 The relationship between teacher knowledge and performance

Killion (1998) acknowledged the impact of teachers' content knowledge on students' learning and stated that teaching for understanding relies on teachers' ability to see complex subject matter from the perspectives of diverse students. The teachers' ability to design questions, select instructional and assessment tasks, evaluate student learning, and make instructional, curricular, and assessment decisions depends on how well they understand the content they are teaching. Killion (1998), however, further mentioned that the teachers' content expertise depends on numerous factors, namely, the teachers' undergraduate or graduate preparation in the content area, how they were taught the subject, and their conceptual understanding of the discipline and hence supporting the influence of teacher education on teacher knowledge. Other factors that may influence teachers' explanatory knowledge relate to the content, the context, the teachers themselves and their students (Treagust & Harrison, 2000).

Goldhaber and Brewer (1998) conducted two studies that showed the impact of teachers' understanding of their content area on student learning. In examining the relationship between teacher knowledge and student learning in mathematics and science, Goldhaber and Brewer (1998) found a significant positive relationship between teachers' degrees and students' achievement. Killion's (1998) report of Social Studies teachers in Hawaii, who were asked to rate their own level of understanding of various historical periods and teaching methods, revealed that students' performance was almost a perfect match; students performed best in areas where their teachers had the most expertise.

Pertaining to the relationship between teacher knowledge and learner achievement, Darling-Hammond (1998) acknowledged a number of recent studies which suggest that teacher expertise is one of the most important factors in determining student achievement. Another factor mentioned was the influence of small schools and small class sizes. That is, teachers who know a lot about teaching and learning and who work in environments that allow them to know students well are some of the critical elements of successful student learning. Similar studies came to conclusions that the most successful teachers had adequate preparation in their subject matter (Armour - Thomas, Clay, Domanico, Bruno, & Allen, 1998; Erickson, 1986; Erickson & Barr, 1985; Ferguson 1991; Ferguson & Ladd, 1996).

However, even in large classes and disadvantaged schools (Nkopodi, 2001) those students who succeeded against the odds in South Africa did so as a result of factors that could be ascribed to various characteristics such as the school vision, the commitment of teachers, the principal and students, the orientation to matriculation examinations, working hard and working together (Malcolm, 2001).

2.2.5 The role of teachers' explanations in mathematics teaching

Researchers in the field of explanations in teaching have argued that explanations provide a rich avenue in enhancing learners' understanding of [mathematics] (Treagust & Harrison, 2000). In the teaching-learning situation, one of the fundamental roles of the mathematics teacher is to provide learners with understandable explanations. 'Explanations are demonstrations of understanding and provide a window to a person's thinking' (Zuzovsky & Tamir, 1999, p.1101). It may be deduced here that a teachers' explanation has a dual purpose. First, it demonstrates understanding of concepts by the explainer. Second, it clarifies and enhances the understanding of taught concept to the learners.

Martin (1970) distinguishes between 'explaining something' and 'explaining a thing to someone'. Explaining a thing may be seen as an activity where say, a researcher undertakes an investigation with the aim of seeking the truth. Explaining a thing to someone, on the other hand, is a pedagogical activity that has the purpose of promoting understanding to a learner. So, when teachers are explaining something, their main aim is to impart knowledge and promote understanding to learners. In fact, an explanation must be capable of making something that was previously unclear to someone, clear (Scriven, 1988). Used in this sense, therefore, the purpose of an explanation is to provide a clarification. Consequently, it is essential for mathematics teachers to provide learners with understandable explanations.

2.2.6 The relationship between explanation and understanding

A call to construct an explanation is essentially a call to exhibit the ability to provide both the appropriate explanation and evidence of understanding (Zuzovsky & Tamir, 1999, p. 1102). Naturally then, when a teacher explains a concept to learners, a measure of the teacher's understanding or lack of understanding of the particular concept is exposed. This is the link that was of interest to this investigation. If a teacher does not understand a concept, it will be difficult for him/her to teach that concept.

2.2.7 The role of pedagogical content knowledge (PCK)

One of the most important aspects of the teachers' explanations in the classroom is pedagogical content knowledge, described as the teachers' special knowledge and skills (Shulman, 1986, 1987). Experience and know-how in PCK is constructed in the classroom. In fact, some researchers have referred to pedagogical content knowledge as expert knowledge (Chi, Glaser, & Rees, 1982) which arises because as teachers work directly with their learners, they are provided with the optimum opportunity to construct a version of reality that fits the experiences in their context (Cochran, De Rutter, & King, 1993). According to Cochran, PCK is knowledge that is constructed from knowing the environmental contexts, knowledge of pedagogy and knowledge of the subject matter. This is the knowledge that has been especially crafted by the teacher to suit the schooling and personal needs of his or her learners. PCK in mathematics includes knowledge of the topics taught, the most useful forms of representation of those topics, the most powerful analogies, illustrations, examples, explanations, and demonstrations (Shulman, 1986). In essence this is a way of representing and formulating the subject such that it is comprehensible to others. As can be seen here, PCK fulfils a number of criteria for expert knowledge because it transcends both subject content and pedagogical knowledge and is consistently and innovatively used to solve classroom-learning problems.

The cited literature showed that good teacher training is essential to effective teaching. Teacher knowledge is fundamental in the teaching and learning of mathematics.

The next section introduces several instruments that may be used to analyse classroom teaching. These instruments are reviewed to illustrate the range of instruments available.

2.3 Instruments for analysing classroom teaching

2.3.1 Introduction

Various classroom observation instruments have been developed to provide both qualitative and quantitative data to document and describe science and mathematics teaching. These instruments have been used by researchers for various reasons to obtain data that would be used to evaluate or determine the impact of intervention programs and to test whether there was change in the practice of pre-service or in-service teachers. A description of some suitable instruments for this study is given in the next section. These instruments could also be used for self-reflection of teachers on their own practice. Other researchers developed rubrics, matrices, models, inventories, conceptual grids and other frameworks to characterise teaching or reform (McIsaac, Sawada, & Falconer, 2001).

The TIMSS videotape classroom study, analysed teaching of Grade 8 mathematics instruction in Germany, Japan, and The United States (Stigler, Gonzales, Kawanaka, Knoll, & Serrano, 1999). In total, the study examined classroom-teaching practices of samples of teachers' classrooms in seven countries through in-depth analysis of videotapes of eighth grade mathematics lessons. The TIMSS 1999, Video study provides rich descriptions of mathematics teaching as these learners were actually experiencing it. The descriptions of the classroom lessons revealed a complex variety of features and patterns of teaching. There were features that were found to be similar to and different from each other in many ways. For instance from a wide-angle view, mathematics teachers in all the seven countries, organised the average lessons to include some public whole-class work and some private individual or small-group work. Teachers in all the countries talked more than students, at a ratio of at least 8:1 teacher to student words (Hiebert et al., 2003).

2.3.2 Constructivist Learning Environment Surveys (CLES)

CLES was developed to enable teachers to measure the extent to which they adopted constructivist ideas in their classes (Taylor, Fisher, & Fraser, 1997). This instrument was initially constructed by Taylor (1991) based on social and personal notions of constructivism whose main reasons were to enhance students' conceptual understanding. CLES was found to be valid and reliable for use within classroom situations through extensive and rigorous processes. Following extensive field testing and instrument validation, the latest version of CLES has 25-items divided equally among five scales specifically related to aspects of constructivism, namely, Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation. CLES is available for personal and class forms, perceived and preferred forms, teachers' and students' forms (Taylor et al., 1997). Each item is responded to on a five-point Likert scale with the alternatives of Never, Seldom, Sometimes, Often and Very Often.

The CLES has been used to explore the effect of special programs designed to improve the student' learning environment (Taylor, Dawson, & Fraser, 1995) and in several studies involving non-Western countries (Aldridge, Taylor, & Fraser, 2000; Idiris & Fraser, 1997; Soeharto, 1998). Kim, Fisher and Fraser (1999) investigated Korean students' perceptions on their classroom learning environment using the more recent version of the CLES.

2.3.3 Science Teaching Efficacy Belief Instrument (STEBI)

Koul and Rubba (1999) cite Bandura (1997) who defines self-efficacy as belief about one's own capabilities to organise and execute a certain task. Self-efficacy beliefs influence thought patterns and emotions, which, in turn, enable actions. Bandura postulated four sources of efficacy expectations, namely, mastery experiences, physiological and emotional states, vicarious experiences, and social persuasion (Bandura, 1997; Tschannen-Moran, Woolfolk - Hoy, & Hoy, 1998). Perceiving one's performance as successful may raise efficacy expectations for future success, just as perceiving one's performance as failure may lower them. Along with degrees of anxiety and excitement, social persuasion and peer-feedback contribute to self-efficacy (Koul & Rubba, 1999).

STEBI was developed by Enoch and Riggs in 1990 to assess efficacy beliefs toward science teaching. The instrument examines teacher efficacy with two sub-scales - personal efficacy (PE) and outcome expectancy (OE). PE items assess teachers' perceptions of their ability to teach science. OE items measure teachers' perceptions that teacher actions will translate into student learning. STEBI was found to be highly reliable (Koul & Rubba, 1999). By substituting mathematics for science, Mathematics Teaching Efficacy Belief Instrument (MTEBI) was developed (Koul & Rubba, 1999), and others such as the Chemistry Teaching Self-Efficacy Instrument (Rubeck & Enoch, 1991). In addition, researchers have conducted studies on efficacy in different contexts, for example, classroom management (Emmer & Hickman, 1990; Raudenbush, Rowen, & Cheong, 1992), special education (Coladarci & Breton, 1997), and the decision-making structure at school (Moore & Esselman, 1992). These instruments do not relate to analysis of classroom issues but deal with the beliefs of the teacher's efficiency but this was not the focus of the study.

2.3.4 Reformed Teaching Observation Protocol (RTOP)

The Reformed Teaching Observation Protocol instrument (RTOP) (Sawada et al., 2000) was developed as an observation instrument to provide a standardised means for detecting the degree to which K-12 classroom instruction in mathematics and science was reformed. RTOP was developed by the Evaluation Facilitation Group (EFG) of the Arizona Collaborative for the Excellence in the Preparation of Teachers (ACEPT) from two instruments: the Horizon Research Inc. instrument and a classroom observation instrument developed by Lawson (1995). The items in RTOP assess five major pedagogical domains: lesson design and implementation; Content: propositional pedagogic knowledge; Content: procedural pedagogic knowledge;

Classroom culture: communicative interactions and Classroom culture: student teacher relationships (McIsaac et al., 2001; Piburn et al., 2000).

RTOP is a 25 item rubric that provides a percentile score describing the degree and kind of student-centred constructivist inquiry present in an instructional situation (MacIsaac & Falconer, 2002). This instrument can be used to catalyse change by engaging teachers in self-reflection on their own practice. The self-reflection process involves watching three videos of their own teaching for 15-minutes, taking notes and making annotations beside the appropriate items. Teachers complete the score sheet and determine a score, which is compared with colleagues, and discuss the difference to arrive at a final composite score for each RTOP item. It is assumed that at the end of these three sessions, reformed teaching would result.

This section has discussed instruments used by researchers to observe teachers of mathematics and science teachers with the purpose of introducing reform. However, these instruments are not directly applicable for addressing the research questions that investigate the practices of teaching and learning of mathematics in township schools.

The next section introduces and discusses the Secondary Teaching Analysis Matrix (STAM) as an instrument that is recommended to analyse classroom practices in township schools to serve the research questions that guided the study under investigation.

2.4 The Secondary Teaching Analysis Matrix (STAM)

2.4.1 Introduction

Researchers in teacher education and staff development are concerned with describing classroom practices in ways that allow comparisons of these practices over a given period of time. The evolution of the matrix to be used in this study was a result of the researchers formulating an instrument to provide a rich description of a range of teaching styles. The matrix format permitted the development of a data set from observing teachers' practice that resulted in a profile of the teacher's teaching at a given time, under specified conditions. This kind of data might be used to determine progress that would lead toward the attainment of more effective approaches to teaching, as the teacher moved toward the goals of the reform (Magill, 2001). Consequently, in order to achieve their aim, these researchers developed what was initially called the Secondary Science Teaching Analysis Matrix (SSTAM), later changed to be shortened as the Secondary Teaching Analysis Matrix (STAM).

2.4.2 Historical perspectives of the Secondary Teaching Analysis Matrix (STAM)

The concept of the Secondary Teaching Analysis Matrix (STAM) began as part of an environmental education project in Thailand. What stimulated the development of STAM was the Salish Research Project that was searching for an instrument to appraise video portfolios of about 150 new secondary science and mathematics teachers. Salish is the name of a native American tribe in the northwest, and is not an acronym for anything. The idea came together in the northwest at a lodge where the Salish Indians were prominent (Magill, 2001).

Subsequently, STAM was constructed by a team of researchers from ten different universities for a Salish 1 Research project in 1994. This instrument was developed by some of the most highly internationally recognised, respected researchers in, and a good amount of thought was poured into its development. The universities involved included:

California State University, Indiana University of Pennsylvania, Michigan State University, Norfolk University, Purdue University, Texas A & M University, the University of Georgia, the University of Iowa, the University of Northern California, and the University of Southern Florida (Adams & Tillotson, 1995).

The researchers wanted to examine the claim that the teaching of secondary science and mathematics by a cross sample of American teachers was student–centred. The Salish team interviewed and analysed teachers' teaching through video–taping and sought a way to record data from these videotapes. In 1995, the Secondary Science Teacher's Analysis Matrix (Magill, 2001) was developed that would determine whether or not the teacher on the videos was either teacher-centred or student-centred. SSTAM was later modified in terms of the structure and content and new titles given to SSTAM was Secondary Teaching Analysis Matrix: Science (STAM: Science) and Secondary Teaching Analysis Matrix: Mathematics (STAM: Mathematics).

2.4.3 The Structure of the Secondary Teaching Analysis Matrix (STAM)

As already indicated, there are two versions of the STAM, one each for science and mathematics which are basically set up in the same way. The STAM is divided into two main parts. The left side of the chart describes traditional teaching styles and the right side of the chart deals with constructivist teaching styles; other teaching styles are in between making a total of six teaching styles. Three of the six teaching styles are traditional and include didactic, transitional and conceptual. The other three are constructivist-teaching styles that include early constructivist, experienced constructivist and inquiry (Gallagher & Parker, 1995; Magill, 2001).

STAM was developed to classify teachers' and students' actions in relation to content, teacher's actions and assessment, students' actions, resources and environment as falling within one of the six teaching styles. STAM consists of rows, which are numbered from 1 to 22, and columns, which are labelled A to F, to denote the six teaching styles, giving a total of 132 cells (Appendix A1 to A5). The 22 rows are further subdivided into five aspects of teaching with each divided into several components (See Appendix A1 (4); A2 (7); A3 (5); A4 (3) & A5 (3)). The number within the bracket indicates the components into which the five aspects are divided.

2.4.4 Descriptions of the teaching styles

2.4.4.1 Introduction

After reviewing instruments used to analyse teaching, for the purpose of this study, three out of the six teaching styles of the STAM (Gallagher & Parker, 1995), namely, didactic, transitional and conceptual teaching were found to be the ones that would provide meaningful data to answer the research questions of the study. Also, as guided by the prevalence of traditional practices in mathematics classrooms from the literature and my own research (Arnott & Kubeka, 1997; Jita, 2002; Ngoepe, 2002;

Ngoepe & Grayson, 2000; Taylor & Vinjevold, 1999), it was reasonable to start at this level. The three teaching styles not considered are constructivist. Descriptions of the teaching styles used in the study are given below.

Didactic teaching

This style refers to a teacher who lectures to students, without any student interaction. The teacher in this style expects his or her students to memorise and regurgitate information (Magill, 2001).

Transitional teaching

This style of teaching is a very descriptive lecture supplemented with cookbook laboratories. Students interact with each other only because they need to complete an assignment. When students are taught by a transition teaching style, they tend not to interact about the conceptual nature of what is to be learned.

Conceptual teaching

Conceptual teaching is the transition style of teaching that will eventually break down the wall of traditional teaching and let in the new teaching styles of constructivism (Gallagher & Parker, 1995; Simmons et al., 1999). With conceptual teaching, the teacher explains ideas to the students, with hands-on activities that are conceptually focused. With a conceptual learning environment, students interact not only because it is a necessary to complete the assignment, but also because they want to complete the assignment. In this teaching environment, students care about making sure the assignment is completed with the least amount of error because they want to be correct. Students who are taught conceptually want to know what they are doing wrong and will often want to correct their mistakes (Gallagher & Parker, 1995).

2.4.4.2 Strengths and weaknesses of STAM

When using the STAM, the researcher assesses teachers' style of instructing by the way he or she portrays the content, by his or her actions, by the way the students interact, by the resources used and the environment of the classroom.

The instrument has proven valid and informative; over the years that it has existed, STAM is claimed to be the best observational instrument known at the present time (Adams & Krockover, 1999). The STAM also served its purpose in the Salish 1 Research project, giving the study accurate information on the teaching styles. Many of the teachers were shocked in how they were teaching their students. However, by the end of the study, most of the teachers changed their style to a more constructivist manner (Magill, 2001). Another positive aspect of STAM is that it examines not only the teachers' teaching but also the students' learning. This assessment tool allows the teacher to know exactly what teaching style he or she is using and how well his or her students are interacting. Only when teachers know the weaknesses in their teaching can they begin to change their instruction.

The STAM needs to be organised for the novice analyser or researcher. When an analyser looks at the STAM for the first time, it seems very complex. This complexity may cause the analyser to feel intimidated (Magill, 2001).

2.4.4.3 The development of STAM

During the process of the development of STAM by a team of researchers, key differences among the four major teaching styles of teaching (didactic, conceptual, constructivist and constructivist inquiry) were defined and discussed by each observable attributes that distinguished them. Consequently, the rubric for each teaching style in each dimension is empirically based, deriving the divisions from the research literature on classroom interactions between teachers and students, teacher knowledge and beliefs and their impact on teachers, constructivist learning, and the personal experiences of the developers (Adams & Krockover, 1997). The sample matrix was drafted and sent to the Salish project members at Purdue University who reviewed the drafts with inputs. The revised draft was distributed to all Salish members in preparation for a Salish meeting that was to be held at Michigan State University in May 1994. Two major actions in formulating and validating STAM were accomplished at the meeting. The first action was to train more than 20 Salish staff members who were present at the meeting to use the instrument. The second action concerned addressing the issue of face validity of the rubric. This was done by letting the Salish staff members review each cell in STAM to determine if the cell appropriately reflected the particular teaching style for which it was intended, and whether the cell presented a clear description that was useful in categorising the component in question.

Several changes in wording of individual cells resulted through this process with three elements being added to STAM to make it more useful and user-friendly. Firstly, a data-recording sheet was created that allowed observers to have all the 132 cells before them at a glance. This made the process of analysing videotapes much easier as observers would be able to see a summary of the whole matrix. It was possible to put STAM in a packet with the detailed matrix, which contained the full description of each cell. This procedure resulted in an 11 x 17-inch sheet that was folded into an 8.5 x11 inch booklet. Secondly, a set of directions for using STAM, with the Salish guidelines for analysing and recording data from videotapes, was printed on the cover of the data-recording sheet to provide users with a summary of the procedures to be used. Thirdly, the back of the booklet served to record two other important elements to the analysis of videotapes. Each of the teachers in the study was asked to prepare a written reflection on the lessons included in the videotapes of three consecutive lessons with the same students. The first element on the back of the booklet was a summary evaluation that was done by the researcher of the teachers' reflections. The second element was a checklist calling for qualitative judgements about nine additional elements that were of interest to the researchers from the videotapes. The nine elements were: accuracy of subject matter content, inclusion of history of scientific ideas, quality of teacher-student interactions, quality of student-student interactions, student behavior, student engagement, transitions from activity to activity, effective use of time, and instructional facilities. A five-point Likert scale was provided for observers to check their overall impressions in each case.

2.4.4.4 Inter-rater reliability of STAM

Salish Research Project 1 concurred with the structure and content of the STAM rubric, thereby indicating content validity. Intersite-rater reliability (Miles & Huberman, 1994) on four training video tapes was 0.83 using the two coders at the research site; coding reliability (Miles & Huberman, 1994) with a time delay of six weeks was 0.86. There are six choices for each of the 22 dimensions. These reliability values are significantly greater than chance and indicating that "more than one observer agrees that the perceived phenomena does exist" (Lauer & Asher, 1988, p. 138).

2.4.4.5 Research studies that used STAM

Adams and Krockover (1997) have used STAM to guide teacher development during the early years of their profession. They described how they made use of STAM coding to characterise classroom behaviours of beginning teachers along the six category continuum of didactic, transitional, conceptual, early constructivist, experienced constructivist and constructivist inquiry as part of a two-year case study where one teacher was provided with a copy of the STAM characteristic descriptor matrix. The following northern autumn, the teacher's teaching style dramatically changed as he deliberately sought to change his STAM ratings, using the STAM matrix descriptors to stimulate recall of experiences and events from his pre-service teacher training which he then deliberately incorporated into his teaching. The teacher's teaching moved from didactic to conceptual.

MacIsaac, Sawada and Falconer (2001) report other researchers, such as Priestly, Priestly Sutman, Schumuckler, Hilosky and White (1998) who described similar usages for their inquiry matrix. In a study that compared student-centred and teacher-centred instruction in a college Biology laboratory, Lord, Travis, Magill and King (2000) incorporated some points from the Secondary Teaching Analysis Matrix – Science (STAM – Science) to analyse students' videotapes for the laboratory sessions. The results of the test showed a significant difference between the constructivist class and the traditional class, with the constructivist group displaying higher scores. In a three-year study, Simmons et al. (1999) investigated the perceptions, beliefs and classroom performances of beginning secondary science and mathematics teachers. In addition to their data collection techniques, STAM was used to code specific behaviours and actions within the teachers' classroom. The general categories for coding the classroom observations included teachers' understanding of content and processes (namely, structure of content ranging from factoids to explanations, to teacher and student negotiation of content), teacher actions (that is, methods of instruction, teacher questions, types of assessments), and student actions (students' questions, student-student interaction), and resources

(Simmons et al., 1999). Magill (2001) reconstructed the Secondary Science Teacher Analysis Matrix (STAM) into a user-friendly likert scale assessment tool called the Secondary Science Teachers Analysis Questionnaire. STAM has proven to be useful, valid and informative in determining the teaching styles used by individual teachers (Magill, 2001).

2.4.4.6 The usefulness of STAM

STAM is an instrument that can be used by researchers, teachers, teacher educators and in professional development programmes for pre-service and in-service teachers. STAM can help to give substance to analysis and interpretation of teaching and classroom environments by allowing a description of classroom actions through a number of constructs. All the 22 descriptors of STAM are essential elements in the daily preparations and delivery of lessons by mathematics teachers. All the five aspects of STAM, namely, content, teachers' actions, students' actions, resources and environment are essential for every single lesson planning, teaching and reflection. For the purpose of this study, all 22 STAM descriptors have been incorporated into the modified STAM version (See Chapter 5; Section 5.2 and Table 5.2) in response to the research questions that guide this study.

2.5 Summary of the chapter

The chapter on the literature started by giving the historical background to the educational system in South Africa in the pre- and post democratic period. A review of studies on teacher knowledge and its relation to performance was presented. Studies that analysed teaching and the different instruments that may be employed are described with reference to successes and failures of the instruments. A detailed discussion of the Secondary Teaching Analysis Matrix (STAM) used in the study for analysing teaching concluded this chapter. The next chapter details the methodology and data collection processes of the study.

CHAPTER 3

METHODOLOGY

3.0 Introduction

The focus of this chapter is on the methodology used in the study. Detailed descriptions and analysis of classroom practices can provide essential information for reforms in helping guide teachers and their students to more successful outcomes. In order to characterise the classroom practices, this study used classroom observations and video tape recordings. Classroom observations were recorded by means of detailed field notes and the videotape recordings were transcribed fully and analysed to yield data for interpretive analysis.

Qualitative methods were used in this study because they are more conducive for research in natural settings and are also free from pre-determined theories and questions, with questions and theories emerging after data collection rather than being posed before the study begins (Guba & Lincoln, 1989; Patton, 1990). A case study approach of research has been used to bring about a better understanding of classroom practices used in township schools.

This chapter presents the methodology that has been used in investigating the practices of mathematics teachers in township secondary schools. Then follows details of the context of 11 observed lessons and one-videotaped lesson with eight teachers in three schools. A description of the framework of Gallagher and Parker (1995) that has been used to characterise and analyse the teaching is given. The chapter concludes by discussing the data analysis, validity and reliability aspects.

3.1 Research questions

The need for assessing classroom teaching for reform purposes has been highlighted in various documents as mentioned in the literature review. This study was carried out with the purpose of gaining insights into the practices of mathematics teachers in South African township secondary schools. The problem investigated gives rise to five research questions that are used to guide the study in township schools in Gauteng, Pretoria.

1. What is the status of the teachers' content knowledge?
2. What is the status of the teachers' teaching?
3. What is the status of the teachers' assessment practices?
4. What is the status of the interaction between the teacher and the students?
5. What is the status of the teachers' resource availability in the schools?

3.2 Research paradigm

Educational research falls within various kinds of paradigms. A paradigm is an interpretive framework that is defined as 'a basic set of beliefs that guides action' (Guba, 1990, p. 17). According to Patton (1990), the criterion used to determine paradigm choice is 'appropriateness' of methodology. This implies that the choice of the methods to be used in a study is dependent on the extent to which the methods 'best fit' the purpose, the research questions and the resources available.

Erickson (1986) categorised approaches that include ethnographic, qualitative, participant observation, case study, phenomenological, symbolic and interactionist and constructive research as interpretive research. Gallagher (1991) maintained that interpretive research methodology allows a study and understanding of the social ecology of transactions that occur in classrooms and in schools between teachers and students, or among teachers and other persons in the educational milieu. An interpretive methodology allows researchers to examine mathematics classrooms as socially and culturally constructed environments for learning, to view the nature of teaching as one feature of the learning environment, and to examine the ways in which teachers and students make sense and give meaning to their interactions as the central element of the educational process (Erickson, 1986). Interpretive studies can provide detailed information about very small samples. As a result, because this research was concerned about the details of teachers' practices in mathematics classrooms, this study used an interpretive research paradigm.

3.3 Research design

The research plan or design for this study is emergent in keeping with a qualitative research design. When pointing out the differences between qualitative and quantitative researchers, Macmillan, (1996) quotes Bogdan and Biklen (1992, p. 58) as they put forward that the difference is that in a qualitative study the researchers enter the investigation "as if they know very little about the people and places they will visit. They attempt to mentally cleanse their preconceptions". Because of this perspective, researchers do not know enough to begin the study with a precise research design. As they learn about the setting, people, and other sources of information, they are better able to know what needs to be done to fully describe and understand the phenomena being studied. Macmillan (1996) further pointed out that qualitative researchers begin the study with *some* idea about what data will be collected and the procedures that will be employed, but a full account of the methods is done *retrospectively*, after all the data have been collected. The design of this study is emergent as characteristic of qualitative research. In the following section, I discuss the case study approach and point out its relation to my study.

3.3.1 A case study approach

Various researchers have given descriptions of case study. For example, Koballa and Tippins (2000) described a case study as "a particular type of narrative which can be used to explicate and clarify the professional knowledge of teachers." Yin (1994) defines a case study as an empirical enquiry that investigates a contemporary phenomenon within its real life context, when the boundaries between phenomenon and context are clearly evident, and in which multiple sources of evidences are used.

Yin (1994) suggested that case studies are the preferred research strategy when the investigator has little control over events and when the focus is on contemporary phenomenon within some real life context. For this research, a case study entails descriptions of the individual teacher's instructional practices.

According to Cohen and Manion (1997), the interpretive, subjective dimensions of educational phenomena are best explored by case study methods. For this reason, a case study approach in my research has been used because it is the most appropriate format for conducting school-based research.

According to Gall, Borg, and Gall (1996), case studies are normally employed in qualitative research for the purpose of producing detailed descriptions of phenomenon, to develop possible explanations of it, or to evaluate the phenomenon. In my study, thick descriptions (Gall et al., 1996) of the phenomenon studied are captured using verbal quotes of the participants. Bailey (1996) acknowledges the subjective understanding and interpretation that the researcher brings to the study in qualitative research. He also recognises that field researchers are influenced by the interpretive process of their history and personality (Bailey, 1996). My experience as a teacher educator for pre-service teachers over a period of 13 years and as a researcher in mathematics education during the past two years will likewise have influenced my interpretation of teachers' lessons and classroom practices.

Interpretive research focuses on individuals studying phenomena in their natural context (Gall et al., 1996). In this research, participant observations were the main data collection method to gain a better understanding of the state of teaching mathematics in a township and record phenomenon in a 'natural setting.'

3.3.2 Essential characteristics of case study research

Merriam (1998) stated that a case study, like research of all kinds, has a conceptual structure organised around a small number of research questions that seek information or revolve around themes. Case studies are concerned about process and meaning rather than outcomes and they rely on fieldwork. Merriam put forward four essential properties of a case study approach. Case studies are particularistic, that is they are concerned about how a particular group confronts a problem. They are descriptive, in other words complete and literal descriptions are provided of the units being studied. Case studies are heuristic in that they illuminate the readers' understanding of the case and are inductive where reasoning is relied on to use the data grounded in the context. My study fulfils the characteristics of case study approach as put forward by Merriam (1998). It is particularistic in that it concerns how a group of mathematics teachers in Grades 10–12 teach the topics in the required curriculum. It is descriptive in that detailed descriptions of the lessons are given. The data used for inductive reasoning is grounded in the context of township schools. The research processes followed in this research are captured in Figure 3.1.

Aspects of the research process	Approach taken
Research paradigm	Interpretive
Research design	Case study
Sample	Teachers
Data collection	Observer
	Videotaped teachers' lessons
Data interpretation	Analysis of cases
Validity	Qualitative component
Ethical issues	Consent
	Confidentiality
	Trustworthiness

Figure 3.1: An outline of the research approach taken in this study (as guided by Mamiala, 2002)

3.3.3 Planning the case study

The following section discusses how the case study was planned.

Negotiating access

Various factors were considered in drawing up the research plan for this study. Negotiating access into schools began at the top of the education hierarchy so that acceptance filtered down (Glesne & Peshkin, 1992). A letter seeking permission was sent through to the district office, to the principal and the teachers stating the purpose of the research and the role of the researcher (See Appendix B; C; D & E). Subsequently, a government official introduced the researcher to the schools to legitimate access and the learners in the class were told about the role of the researcher. Rapport was established with the teachers concerned to develop an element of trust and cooperation so that there was more opportunity to obtain quality data.

The importance of gaining access into schools enables the researcher to gain consent to go where he/she wants, observe what he /she wants, talk to whomever he/she want, obtain and read whatever documents he/she requires, and do all this for whatever period of time needed to satisfy research purposes (Zevenbergen, 1998). On entering the class, my role was to observe the 'natural' setting of classroom events with no attempts made to influence any changes. In this role, I was in a better position to observe how the teacher taught the content and what instruction he/she used, what kinds of interaction existed between the teacher and the learners, what kinds of tactics and strategies learners used and the types and forms of artefacts present in the classroom.

Sample

The choice of the sample was done in consultation with the Department of Education on the recommendation of the local Education District Official and with the consent and willingness of the school principal and the mathematics teachers themselves. All the mathematics teachers of Grades 10-12 in three schools were requested to be part of the sample. Two of the three schools had three teachers each and one school had two teachers as part of the sample (see Table 3.4). Subsequently, eight secondary mathematics teachers of Grades 10 - 12 in three township schools in Gauteng Province of South Africa were involved in the research. The choice of the sample schools was also influenced by their proximity to UNISA where I work.

The township schools involved in this study were in many ways representative of schools in South African townships which are characterised by a range of contextual factors that could limit individual teacher's attempts to bring about change in their classrooms (Clark, 1999; Taylor & Vinjevold, 1999). These schools were part of the previously segregated communities and were subject to Bantu Education that was imposed under apartheid (Malcolm, 2001; Nkabinde, 1997; Taylor & Vinjevold, 1999). A description of townships and their evolvement has been given in Chapter 2. The names of schools as used are pseudonyms.

Ethics

Ethical issues in the research involved voluntary participation based on informed consent. In other words, the participants had a choice of whether or not to participate in the research. The initial sample was four schools but one of the schools that was chosen as part of the sample withdrew. Access into the teachers' classrooms was continuously negotiated and renegotiated often through telephonic communication. The use of pseudonyms in report writing ensured confidentiality and anonymity of the teachers and the schools. As indicated earlier, the teachers were informed of the role of the researcher as that of seeing and documenting their routine daily practices. As an observer, I did not interfere with the classroom activities so that the locus of control remained with the teacher. The teachers and the learners were told that the purpose of the observation was for research and that the researcher would document all the activities that occurred in the classroom. The teachers and the learners were willing to be observed in their classroom and learners often offered to share a seat with me.

3.3.4 Methods for collecting data

In this study the following methods were used to collect data.

Field notes of observations

Classroom observations were recorded in the form of detailed field notes. These were taken regularly and promptly, writing everything down no matter how insignificant it seemed at that time and were analysed frequently (Bogdan & Biklen, 1992; Creswell, 1994; Lofland, 1971). Reflective notes were used to provide the researcher with a record of personal thoughts, which included speculations, feelings, ideas, hunches, impressions and prejudices, as well as descriptions of what was being observed. Direct quotes provided an emic perspective which is at the heart of most ethnographic research and which generated insights and interpretation (Patton, 1990). As much as possible of the observable information was recorded, for example, whatever was written on the chalkboard in the form of diagrams, solutions to problems, artefacts or posters.

Informal discussions were held with teachers after the lesson and these were recorded. No suggestions were made to correct the lesson but rather to listen to what the teachers said. The topics being taught were not pre-arranged. The idea was to observe the situation as it unfolded so as to capture as much as possible to depict the natural classroom activities in mathematics. The verbal and written words of the teacher and the learners were important, so what the teacher and the learners did was recorded. If the teacher or the learner was speaking in his or her mother tongue this also was recorded and later translated by the writer in report writing.

Teacher participation

Voluntary participation was sustained through continual negotiation and renegotiation to nurture relationships for the sake of the research. This was also done through phoning the teachers a day before the visit or on the morning thereof to ensure that my visit was convenient and would be fruitful. There were times when the teachers told the researcher that they would be having an emergency staff meeting or an urgent request or submission to the Department of Education. In this case, the lesson would be scheduled for another day when it was convenient for the teacher and the researcher. For instance, at one time when there was no water at the school, classes had to be dismissed and the lesson was postponed to some other time.

One video recording of a lesson was made to be certain to capture everything that transpired during instruction and also to provide further validation of the field-note recordings. Because the presence of the researcher or video camera in the classroom can threaten the validity of the study, the teachers were informed of my interest in capturing a typical day in their classroom for research purposes.

3.4 The school context

The schools used in this study are in a township and are situated on the outskirts of the City of Pretoria, which is South Africa's administrative capital. In this section, the schools and their teachers are described. Table 3.1 gives a summary of information about the teachers, the number of lessons observed, the teachers' qualifications and years of experience.

The data collection part of the research took place during two separate periods between May 2001- September 2001 and in May 2002-June 2002. Videotaping was done in the second period. The official duration of the class periods were 30 minutes in an ordinary high school and 45 minutes in a technical school. The number of learners per class ranged between 30 and 50.

3.4.1 School T and the teachers

School T is a secondary high school enclosed by a thick fence and has a number of blocks with many classrooms, including a laboratory, a library, and school grounds. The school buildings are built with brick and are very solid and all the learners wear school uniform. However, there are few books in the library, which is used by some teachers as an office. The library books were old and appeared not used by learners. The laboratory functions as a science classroom and has dusty dysfunctional equipment. Some of the classrooms also are very dirty and others clean. The school furniture in the classrooms looks old. Most of the desktops have uneven surfaces full of writings, which in most cases resulted in damaging the tops of the desks. Very few writings on the desks are subject related. Most are musician names; clothes labels while others are learners' names which seemed to have accumulated over a number of years. Most of the learners are from squatter camps. School T had 1300 learners and 38 teachers and is about 5km from School K and School D. At the time of data collection, the principal in School T was in an acting capacity. One of the caretakers opens the gate when there is a visitor at the gate.

Table 3.1 Learners' examination results in mathematics for School T at Grade 12 Higher Grade (HG) and Standard Grade (SG) in 2002 from the school office.

Year	Number of learners who wrote Grade 12 Examination		Learners' examination results: [1, 2, 3]	
2001	HG	SG	HG	SG
	4	55	4H	4F 3GG H48
2002	HG	SG	HG	SG
	4	54	4H	1F 3GG 50H

1. Passing Grades: B: 70 - 79; C: 60 – 69; D: 50 - 59; E: 40 – 49
2. Failing Grades: F: 33 – 39; G: 30 – 32; GG: 20 – 29; H: 0 – 19
3. The numbers refer to percentages

Participating teachers in School T

Ms Makola, in her late twenties, holds a Secondary Teachers Diploma (STD) and is a temporary teacher who teaches Grades 8, 9 and 12 Mathematics. She has five years of teaching experience.

Mr Mosotho is a young teacher, in his late twenties, who has four years experience and taught Grades 10-12 Mathematics and Grade 9 General Science. His qualification is a Secondary Teachers' Diploma (STD) with a major in mathematics.

Mr Lekgau has been teaching for 19 years and holds a Primary Teachers' Certificate (PTC). He is currently registered for a Further Education Training (FET) with one of the Universities and his specialisation subject is mathematics; other subjects are computer, technology and physical science. He has been involved in marking Grade 10 examinations.

The average pass rate in Mathematics at Grade 12 for School T in 2001 was 5% for Higher Grade (HG) and 10% for Standard Grade (SG). The Grade 12 Mathematics results for School T for the years 2001 and 2002 and the symbol distribution are given in Table 3.1. Data for 2000 were not available.

3.4.2 School K and the teachers

This is a technical high school where all the learners take Mathematics from Grades 8 to 9; from Grade 10, Mathematics is optional but most of the learners do take Mathematics. School K is about 800m from School D. Similar school features as described in School T are prevalent. The female principal is a white South African as are several teachers in this school. A security guard at the gate opens and closes the gate. The technical school K is fairly well resourced and has a computer laboratory, library and a laboratory which is also used as a classroom. School K was one of the Secondary Intervention Program (SIP) schools and has a Saturday program funded by the government to improve standards in very low achieving schools. The tutors of SIP were mathematics teachers from different schools. School K had 1400 students and 36 teachers.

Participating teachers in School K

Ms Mogotse is in her late thirties, holds a Secondary Teachers Diploma (STD) and she studied mathematics and chemistry for four years at university. She has been teaching for six years and she teaches Grade 8 and 10 Mathematics and Grade 12 Physical Science.

Mr. Muntu is a vice principal and teaches Grades 10-12 mathematics. He is in his middle forties and holds a two-year Junior Secondary Teachers Certificate (JSTC), which he obtained from one of the Colleges of Education, with a mathematics major. He also holds a one-year Higher Education Diploma, and a Bachelor of Arts (B.A) degree. He has 19 years of teaching experience.

Mr Naka is in his late thirties, has 13 years teaching experience and is currently teaching Grades 8, 9, and 12 Mathematics. His professional qualification is a three - year Secondary Teachers Diploma (STD) with majors in mathematics, physics and chemistry.

The average pass in Mathematics for the school at Grade 12 in 2001 was 16% for Higher Grade (HG) and 15% for Standard Grade (SG). The Grade 12 results for School K for the year 2002 and the symbol distribution are given in Table 3.2. Data for 2000 and 2001 were not available.

3.4.3 School D and the teachers

This is a technical school with 1100 learners, who also wear a school uniform, and 30 teachers. Similar features as in Schools T and K are noticeable. All the learners in this technical college take Mathematics as one of their subjects up to Grade 9 and from Grade 10 Mathematics is optional.

During my observation period, on approaching School D, learners, usually boys, would be seen roaming around the toilet areas in groups casually talking, with some students smoking. The gate was always locked. The classes are very spacious and learners tend to crowd towards the back, leaving space in the front of the classroom. Learners are seated on desks that accommodate two learners. The classrooms of

School D are poorly furnished. In some classrooms there is a teachers' table whilst there is no table in others and there are no cupboards and few pictures on the walls. The schoolyard was neglected and marked by papers and dirt around the yard. Some of the girls dress like boys and sometimes it was difficult to recognise who the girls were even from their hairstyle. A computer laboratory was donated to the school by a company, which also built a solid wall around the whole school. However, as observed, these computers, especially during examination times, were mostly used by teachers to produce mark sheets and question papers.

Table 3.2 Learners' examination results in Mathematics for School K at Grade 12 Higher Grade (HG) and Standard Grade (HG) in 2002 from the school office

Year	Number of learners who wrote Grade 12 Examination		Learners' examination results: [1, 2, 3]	
2002	HG	SG	HG	SG
	14	100	1GG	1C
			13H	7E
				4F
				12GG
				76H

1. Passing Grades: B: 70 - 79; C: 60 – 69; D: 50 - 59; E: 40 – 49
2. Failing Grades: F: 33 – 39; G: 30 – 32; GG: 20 – 29; H: 0 – 19
3. The numbers refer to percentages

Participating teachers in School D

In his late thirties, Mr. Timba holds a Technical Diploma and has been teaching for 14 years. He was teaching Mathematics in Grades 11 and 12.

Mr Nare, a teacher in his late thirties, teaches Grades 8, 9 and 10 Mathematics and holds a three-year Technical Diploma in Civil Engineering, Building and Plastering, that includes two years of Mathematics. He has been teaching for 15 years and has taught Mathematics and Art and Culture.

The average pass in Mathematics in Grade 12 for School D in 2001 was 29% Higher Grade (HG) and 24% Standard Grade (SG). The Grade 12 results for School D for the years 2000 to 2002 and the symbol distribution are shown in Table 3.3. Data for years 2000 and 2001 were incomplete.

Table 3.3 Learners' examination results in mathematics for School D Grade 12 Higher Grade (HG) and Standard Grade (HG) from 2000 to 2002 from the school office

Year	Number of learners who wrote Grade 12 Examination		Learners examination results: [1, 2, 3]	
2000	HG	SG	HG	SG
	4	59	1D	1D
			1E	4E
				13F
				7G
				26H
2001	HG	SG	HG	SG
	3	31	1D	1B
				2D
				3E
				7F
2002	HG	SG	HG	SG
	5	29	1D	1B
			1GG	2D
			3H	2E
				2F
				4GG
				18H

1. Passing Grades: B: 70 - 79; C: 60 – 69; D: 50 - 59; E: 40 – 49
2. Failing Grades: F: 33 – 39; G: 30 – 32; GG: 20 – 29; H: 0 – 19
3. The numbers refer to percentages

The number of lessons observed from each teacher, which differed from class to class and from school to school, is shown in Table 3.4. Some teachers were observed only once while others were observed several times depending on the circumstances. The academic and professional qualifications of the teachers are also presented in Table 3.4.

Table 3.4 Information about the teachers, the number of lessons observed, the teachers' qualifications, and years of experience

Schools	Number of lessons	Teacher qualification	Years of experience
School T			
Ms Makola	1	Secondary Teachers Diploma	5
Mr Mosotho	2	Secondary Teachers Diploma	4
Mr Lekgau	1	Primary Teachers Certificate; Further Education Teaching	9
School K			
Mr Muntu	2	Junior secondary teachers' Certificate; Higher Education Diploma, Bachelor of Arts	19
Ms Mogotse	1	University Course	6
Mr.Naka	2	Technical Diploma	13
School D			
Mr Timba	1	Technical Diploma	14
Mr Nare	2	Technical Diploma	15

3.4.4 Lessons

A summary of lessons that were observed with the grades and the teachers are recorded in Table 3.5.

3.4.5 Disruptions of schooling during data collection

During data collection, there were several occasions when disruptions occurred. Such disruptions during data collection in South Africa are a common phenomenon as documented by Vithal (1998):

> If you talk to any educational researcher in South Africa who is collecting data, you will find that he or she has consistent stories of arriving at a school after careful and extensive discussion only to find the school completely empty or having new management, disrupted by protests, or some other unanticipated situation. Disruptions to carefully conceived plans are the norm rather than the exception. Thus disruptions experienced in research designs produce disruptions in the data. Such disruptions may or may not be severe

but their impact on researcher intent to continue with the same research focus or question, may be crucial. (Vithal, 1998, p. 475)

Table 3.5 Summary of observed mathematics topics in lessons taught by teachers and student grade level.

Topic	Grade	Teacher	*Learners/class
Simultaneous Equations	11	Mr Timba	43
Changing the subject of the formula	10	Ms Mogotse	39
Compound interest and depreciation	12	Ms Makola	30
Limits of functions	11	Mr Mosotho	46
Geometric Sequences	12	Mr Lekgau	39
Trigonometry	10	Mr. Nare	44
Multiplication of terms	11	Mr.Mosotho	45
Converse of theorem 1	11	Mr.Muntu	44
Gradients of parallel and perpendicular lines	12	Mr. Naka	16
Linear graph	10	Mr.Nare	32
Mid points of lines	12	Mr.Naka	39
Perpendicular Bisector	12	Mr. Muntu	45

* Indicates the number of learners present during the lesson

Similar disruptions were experienced during my data collection period. On one occasion an appointment was made to discuss when to commence with the lesson observations at School T and also to obtain the timetable of Mr. Mosotho's teaching. Upon arrival at the school, I learned that Mr. Mosotho would be absent for a week arranging a funeral for a brother.

Similarly, in School D, on arrival both the mathematics teachers went to the Department of Education to report and discuss the case of Mr. Nare who appeared as a witness in a murder case of a colleague on their way to school. Subsequently, he was to appear as a state witness in this case. As a result, Mr. Nare was absent from school for some time in fear of being victimised. In another instance on arrival at School D, there was an emergency staff meeting to discuss examination-related issues.

On another occasion when I visited School T, the Head of the Department, who was to be observed, was solving a personal problem of a learner who had been abused by her fiancée. Fellow learners wanted to take action and deal with the abuser and the teacher was advising them to not do this and report these matters to the police. The learners were adamant that the matter had been reported to the police before but the police had done nothing about the issue up to that point. Both the learners and the teacher missed their classes whilst involved in discussions to resolve this personal matter. In School D, one of the mathematics teachers in my sample had been expelled by the Education Department because of a case that related to sexually abusing a learner.

3.4.6 Analysis of cases

The process of data analysis is eclectic, that is there is no 'right way' (Tesch, 1990). Analysis of any kind involves a way of thinking that includes a 'systematic study of a phenomenon to determine its parts, the relationship among parts and their relationship as a whole' (Spradley, 1980, p. 85). Analysis involves interpretation and synthesis of data obtained from each case with the aim of discovering patterns, ideas, explanations and understandings of participants' behaviour.

This study used an inductive data analysis procedure in keeping with qualitative research. The data were gathered first then synthesised inductively to generate generalisations. Theory was developed from the 'ground up', or ' bottom up' from detailed particulars rather than from the 'top down'. In this study, I analysed each lesson and then came up with an insight that meant "creating a picture from the pieces obtained" (McMillan, 1996, p. 240). As much of verbatim quotations as possible were included in the analysis for credibility and in support of my argument. Patton (1990) recommends both openness and integrity in conducting fieldwork and in reporting results. The discipline and rigor of qualitative analysis depend upon presenting descriptive data, which is often called thick description (Denzin & Lincoln, 1994), in such a way that others reading the results can understand and draw their own interpretations.

3.4.7 Coding

Coding involves establishing units of analysis of the data, indicating how these units are similar to and different from each other (Cohen, Manion, & Morris, 2000). The use of codes enables ways to define and locate items within the data records" sampling, identifying themes, building blocks, …" (Ryan & Bernard, 2000, p. 780).

In this study, various formats of coding were employed as recommended by Mamiala (2002) and there are differences in coding for observed and video-recorded lessons. For example, Dtl/ 090501/Gr is an example of coding for an observed lesson. The first letter identifies the school, the second letter and number, the teacher and the lesson topic, then the date, month and year, lastly, the grade. In the case where the lesson was videorecorded, the following format was used Dt1v/ 070602/Gr where v after the school identifies the videotaped lesson.

3.5 Description of the theoretical framework

3.5.1 Introduction

I adopted the framework for this study based on the Secondary Teachers' Analysis Matrix (STAM) that was designed for the Salish project to assess whether mathematics and science teachers' teaching styles were student-centred or teacher-centred (Gallagher & Parker, 1995). The rubric in STAM typifies teaching along a six-category continuum, namely from didactic, transitional, conceptual, early constructivist, experienced constructivist to constructivist inquiry. A detailed description of the Matrix appears in Appendix A1 to A5. However, based on my experience as a teacher educator, my own research with pre-service and practicing teachers and after reading the relevant literature (Arnott & Kubeka, 1997; Hobden, 2002; Jita, 2002; Mosimege, 2000) for this research, the framework was truncated to a three-category continuum of didactic, transitional and conceptual teaching. The right side of the STAM matrix is more oriented to constructivist teaching (Adams & Krockover, 1999; Magill, 2001) which was little in evidence in studies of South African classrooms. Informed by the literature and experience in teacher education in South Africa, as mentioned earlier, the left side of the STAM was found appropriate to analyse teaching for the purpose of this study. This framework was used to carefully analyse the 11 observed lessons and the one example of the videotaped lesson.

3.5.2 The structure of the secondary Teaching Analysis Matrix

STAM consists of rows, which are numbered from 1 to 22, and columns, which are labelled A to F to denote the six categories (See Appendix A1), resulting in a 6 x 22 matrix of 132 cells. For this research, the columns are labelled from A-C denoting three categories- didactic, transitional and conceptual.

Table 3.6 The structure of the rows in STAM (Gallagher & Parker, 1995)

Content (4 rows)

1.Structure of content
2.Use of examples
3. Limits, excerptions, and multiple interpretations
4. Processes and history of maths

Teachers' actions and assessment (7 rows)

5. Teaching methods
6. Labs, demonstrations, and hands on activities
7. Teacher student interaction
8. Teacher questions
9. Kinds of assessment employed
10. Uses of assessment beyond grading
11. Teacher's responses to student ideas

Students' actions (5 rows)

12. Writing and other representations of ideas
13. Students questions
14. Student-student interaction
15. Student-initiated activity
16. Student understanding of teacher expectations

Resources (3 rows)

17. Richness of resources
18. Uses of resources
19. Access to resources

Environment (3 rows)

20. Locus of decision-making
21. Teaching aids displayed
22. Students work displayed

The 22 rows are further subdivided into five aspects of teaching. Each rubric is divided into several components shown in Table 3.6.

In the next sections, each framework is described to indicate how it was used to analyse the 12 lessons. The coding, for example STAM 1A, is used to refer to the relevant characteristics for each lesson that is analysed in Chapter 4.

Content

Using the STAM framework (Gallagher & Parker, 1995), the content of teaching was characterised as *didactic teaching* when:

- The structure of the content is in the form of factual content and factoids. (STAM 1A)
- There are no examples or connections to (a) real world events, (b) related ideas, or (c) key ideas of the subject. (STAM 2A)
- The limits, exceptions, and multiple interpretations are oversimplified so that the limits or exceptions within content are not presented. Many statements are absolutes without qualifiers. (STAM 3A)
- Processes and history of mathematics are distinguished as no explicit mention of how we know. Mathematical method is presented separately as static or algorithmic approach. (STAM 4A)

In *transitional teaching*, content using the STAM framework is characterised by the following features:

- Content tends to be descriptive with concepts and factoids given equal emphasis. (STAM 1B)
- There is use of examples and/or related ideas separate from other pieces of content. (STAM 2B)
- Some limits, exceptions, and alternate interpretations are included, but are not integrated with other content. (STAM 3B)
- No explicit mention is made of how we know. Processes of mathematics such as observation and inference are not integrated with content. (STAM 4B)

In *conceptual teaching,* content is characterised using the STAM framework by the following features:

- Content tends to be explanatory with conceptual content organised around key ideas. (STAM 1C)
- Use of examples and connections are made by the teacher to (a) real world events, (b) related ideas and (c) key ideas of the subject. (STAM 2C)
- Limits, exceptions, and alternate interpretations are presented as part of the content. (STAM 3C)
- "How we know" is included in the content. The teacher integrates processes of mathematics with concepts. (STAM 4C)

Teachers' actions and assessment

Using the STAM framework (Gallagher & Parker, 1995), the teachers' actions and assessment are characterised as *didactic teaching* by the following features:

- One or two teacher-centred methods predominate. (STAM 5A)
- Demonstrations and hands-on activities are not used. (STAM 6A)
- Little-teacher student interaction about subject matter (chalk and talk). (STAM 7A)
- Teacher's questions call for factual recall. (STAM 8A)
- Assessment is in the form of tests and quizzes only. (STAM 9A)
- There are no uses of assessment beyond grading. (STAM 10A)
- The teacher disregard students' ideas about subject matter. (STAM 11A)

In *transitional teaching*, the teachers' actions and assessment using the STAM framework are characterised by the following features:

- Three or four teacher-centred teaching methods include some hands-on activities. (STAM 5B)
- Some demonstrations or hands-on activities which are either overly directed (cookbook) or undirected (e.g., exploration without follow-up). (STAM 6B)

- Teacher–student interaction about correctness of students' ideas about unconnected facts. (STAM 7B)
- Teachers' questions are directed towards mathematical ideas, not towards connections or applications, and they do not build on students' responses. (STAM 8B)
- Occasional checking of students' knowledge in addition to tests and quizzes. (STAM 9B)
- Checking students' knowledge. (STAM 10B)
- The teacher may accept all students' ideas and also view students' unmathematical ideas as oddities. (STAM 11B)

In *conceptual teaching,* the teachers' actions and assessment using the STAM framework are classified by the following features:

- There is a rich repertoire of teacher-centred methods, including hands-on activities. (STAM 5C)
- Many demonstrations or hands-on activities are conceptually focused. Answers are generally known ahead of time. (STAM 6C)
- Teacher-student interaction about correct-ness of students' knowledge of conceptual content. (STAM 7C)
- Teachers' questions are directed towards knowledge of mathematical concepts and their connections and applications but they do not build on students' responses. (STAM 8C)
- Frequent checking of students' knowledge in addition to tests and quizzes. (STAM 9C)
- Checking students' knowledge and preplanning. (STAM 10C)
- Teacher investigates students' ideas about subject matter and works to alter "unmathematical" ideas. (STAM 11C)

Students' actions

Similarly, using the STAM framework (Gallagher & Parker, 1995), students' actions are characterised as *didactic teaching* by the following features:

- Writing and other representations of ideas are not used and only short answers from students predominate. (STAM 12A)
- There are few students' questions. (STAM 13A)
- Student–student interaction is rare or nonexistent. (STAM 14A)
- Students rarely volunteer examples or analysis. (STAM 15A)
- Students are passive or ignore the teacher's procedures. (STAM 16A)

In *transitional teaching*, students' actions are characterised using the STAM framework by the following features:

- Writing and other representations of ideas are rarely used. Most are reconfigurations of information provided. (STAM 12B)
- Students' questions clarifying procedures dominate. Some questions ask for clarification of terminology or repeat of information. (STAM 13B)
- Some student-student interaction, mostly about procedure. (STAM 14B)
- Students volunteer a few examples, but connections to class activities may be weak. (STAM 15B)
- Students show confusion over procedures. (STAM 16B)

In *conceptual teaching,* the students' actions are characterised using the STAM framework as:

- Several forms of writing and other representations of ideas are used. Most are reconfigurations of information provided. (STAM 12C)
- Student questions focus on clarification of meaning related to specific concepts or procedure. (STAM 13C)
- Some student–student interaction about procedure. Some about articulating mathematical ideas correctly. (STAM 14C)
- Students volunteer some examples related to class activities. (STAM 15C)
- Students accept procedures and role. (STAM 16C)

Resources and environment

Using the STAM framework (Gallagher & Parker, 1995), resources and environment are characterised as *didactic teaching* when:

- Resources are little beyond single text or format. (STAM 17A)
- Students look at, but do not actively use resources and when resources are not related to content. (STAM 18A)
- Access to resources is controlled by the teacher. (STAM 19A)
- The locus of decision-making is teacher dominated. (STAM 20A)
- Few teaching aids are displayed and may not be integrated with the content. (STAM 21A)
- Few examples of students' work are displayed. (STAM 22A)

In *transitional teaching*, resources and environment are characterised using the STAM framework by the following features:

- Text and small number of resources, including some hands-on. (STAM 17B)
- Resources are not related to content. (STAM 18B)
- Access to resources controlled by the teacher. (STAM 19B)
- Little sharing of decision-making with students. (STAM 20B)
- Some teaching aids are displayed and may not be related to the content. (STAM 21B)
- Students' work displayed is typically similar for all students. (STAM 22B)

In *conceptual teaching*, resources and environment are characterised using the STAM framework by the following features:

- Multiple resources, i.e. visual aids, videos, manipulatives, technology, or people. (STAM 17C)
- Resources are related to content and illustrate ideas. (STAM 18C)
- The teacher controls access to resources, but there is some discussion of access with students. (STAM 19C)

- Some sharing of decision-making with students about use of time. (STAM 20C)
- Many teaching aids related to the content are displayed. (STAM 21C)
- Some variations in students' work are displayed. (STAM 22C)

3.6 Validity

In interpretive studies, Guba and Lincoln (1989) argued that validity means that the data should be trustworthy, credible, transferable and dependable. Lincoln and Guba (1985) propose using the term truth-value for internal validity. Internal validity addresses the question of how one's findings match reality and is a measure of whether the findings capture what is really there or whether the researcher is measuring what he /she thinks is being measured. According to Lincoln and Guba (1985), reality is "a multiple set of mental constructions... (p. 95). Furthermore, reality is holistic, multidimensional, and ever-changing; it is not a single, fixed, objective phenomenon waiting to be discovered, observed, and measured (Merriam, 1988, p. 167). Judging the validity or truth of the study rests on the researcher showing that "he or she has represented the multiple constructions adequately and that the reconstructions that have been arrived at through the investigation are credible to the constructors of the original multiple realities (Lincoln & Guba, 1985).

To ensure trustworthiness, Guba and Lincoln (1989) suggested six criteria to judge this, which are prolonged engagement in the research environment, persistent observation, peer debriefing, negative case analysis, progressive subjectivity and member checks. In this study, credibility also entailed that I had the responsibility of interpreting what I observed, heard or read. Interpretation must include the perspectives and voices of the people studied (Strauss & Corbin, 1994). Moreover, Glaser and Strauss (1967) recommended that judging the credibility of theory should be sought through exhaustive reporting of one's settings, data and methods and a carefully reasoned argument. In this study, credibility was sought by descriptions of the data sources.

3.6.1 Validity of the classroom observations

One major concern was that the presence of the researcher or the video camera would alter the nature of the classroom instruction and thus threaten the validity of the research. To increase credibility the teachers were informed that the observations were for research purposes in order to try and find ways of improving the teaching and learning of mathematics in township schools. It was also explained that a new Science Education Centre at UNISA was in the planning process of providing professional development for mathematics teachers and that this planning would be done more effectively if informed by research findings in local schools. The results did not appear to be influenced by my presence or the video camera. I sat at the back of the class and observed that the teacher and the learners seemed to be absorbed in what they were doing and seemed not to do anything extraordinary or pay attention to me.

Another key issue was the number of times that the teachers were observed and video taped. If a valid and reliable picture of individual teachers teaching is to be given, then there is need to observe the teacher multiple times. Furthermore, different teachers were observed in order to limit bias to one teacher or class and to have a general picture of what happens in the mathematics classes of the three schools. On the other hand, videotaping each teacher once limits the kind of generalisations that one can make about instruction. Validity was also achieved by detailed reports that included the voice of participants, as described by Gall et al. (1996), as "reconstructing the participants' phenomenological reality" (p. 574). Constant inclusions of extractions from the teachers' lessons were used to enhance credibility.

3.6.2 Reliability

In qualitative research, reliability refers to the extent to which one's findings can be replicated. Since there are many interpretations about what is happening, there is no benchmark by which one can take repeated measures and establish reliability. Guba and Lincoln (1989) suggested that we should think about dependability or consistency of the results obtained from the data. That means we rather should consider whether or not outsiders "concur that given the data collected, the results make sense" (Merriam, 1988, p. 172).

In this study, reliability has been achieved by explaining the assumptions and theory behind the research, the position of the researcher in relation to the sample studied, the basis of the selection of the sample, descriptions of the sample and the social context from which the data were collected. Dependability also has been achieved by triangulation using multiple methods of data collection which has been used to strengthen reliability and internal validity of the findings.

Consistency of the results using STAM in the form of intersite reliablity was achieved by using two coders who discussed cross validation in order to achieve consensus. An indication that when "more than one observer agrees that the perceived phenomenon does exist" (Lauer & Asher cited in Adams & Krockover, 1997, p. 651) supports the reliability of the instrument.

3.6.3 External validity

Guba and Lincoln(1989) propose that the term transferability be used for external validity which essentially refers to the extent to which the findings of the study can be applied to other situations. Generalisability can be achieved through seeking an in-depth understanding of the situation that is being studied.

The contention made by Erickson (1986) is that "the production of generalisable knowledge is an inappropriate goal for interpretive research. In attending to the particular, concrete universals will be discovered. ... the search is for *concrete universal* (his italic) arrived at by studying a specific case in great detail and then comparing it with other cases studied in equally great detail" (p.130). In this study, analysis of lessons in detail is designed to bring about this kind of understanding.
Thus generalisability of results in this sense can be achieved through the researcher providing detailed descriptions of the study's context. "The description must specify everything that a reader may need to know in order to understand the findings" (Merriam, 1988, p. 125).

3.7 Summary of the chapter

The purpose of this chapter was to describe the methodology that was used in the study and the various stages of the research. Information about the schools, the teachers and the lessons that were taught were presented. For the purpose of this study, it was necessary to investigate the state of mathematics teaching in township secondary schools. The framework of Gallagher and Parker (1995) was used to characterise the nature of teaching in terms of the content, the teachers' actions and assessment, students' actions and resources and environment. Chapter 4 reports on the results of the analysis of the lessons using the STAM.

CHAPTER 4

RESULTS

4.0 Introduction

This chapter presents the results of the study. The major data collection methods used were classroom observations and videotaped lessons. A detailed description of the instrument that has been used to analyse the data has been given in Chapter 3. Eleven observed lessons and one-videotaped lesson were analysed in terms of the identified 22 descriptors from the Secondary Teaching Analysis Matrix - Mathematics (STAM-Mathematics) (Gallagher & Parker, 1995).

The principal research problem to be investigated in this study is the practices of mathematics teachers in township schools.

The five research questions that guided the study were:

1) What is the status of the teachers' content knowledge?
2) What is the status of the teachers' teaching?
3) What is the status of the teachers' assessment practices?
4) What is the status of the interaction between the teachers and the students?
5) What is the status of the resource availability in the schools?

Chapter 4 is structured by naming each lesson and providing a code to be able to identify it; for example, Dt1/090501/Gr11 locates the school, the teacher and the lesson, the date and the grade. Based on the field notes, the description of each lesson follows with the researcher's comments on the lesson. To aid analysis, each lesson has been divided into parts, for example [Part 1]. The indented sections of the lesson description denote what the teacher wrote on the chalkboard about mathematics problems during the lesson. The researcher's interpretations or reflections on the teacher's utterances or statements are provided and when they occur in the text these are identified by Comment: and a statement written in italics. However, some lessons do not have the researcher's comment because they have been included in the lesson proceedings. The analysis of the lessons using the 22 descriptors of the framework of

Gallagher and Parker (1995) (Appendix A1[A-C] to A5[A-C]) is denoted by the headings, content, the teachers' actions and assessment, students' actions, and resources and environment. On the basis of each of these descriptors, the lesson is justified as being didactic (STAM A), transitional (STAM B) or conceptual (STAM C). To indicate that there were attributes of transitional or conceptual teaching to distinguish them these were identified as transitional (STAM AB) or conceptual (STAM BC). A presentation of the overall summary of the findings in Table 4.1 concludes the results using the framework of Gallagher and Parker (1995).

4.1 Simultaneous equations

4.1.1 Description of the lesson (Dt1/090501/Gr11)

In this lesson, the teacher, Mr. Timba, was teaching simultaneous equations and was discussing a problem that had been given as a group work assignment. Firstly, he wrote the two equations on the chalkboard: $3x - 4y = 7$ and $2x^2 + xy + 3y^2 = 4$. His discussion with the class was predominantly teacher-centred with questions asked of students to achieve a desired answer. The lesson began as follows:

[Part 1]

T: What is the first step [in solving the two equations]?

L: (Learners responded in a chorus) $3x = 4y + 7$

T: Do you mean that 4 is positive? (Spoken as: *Le ra gore 4 e positive?*)

T: What is the next step?

L: $x = \frac{4y+7}{3}$ (Learners respond in a chorus)

T: What do we do with x?

L: (In chorus) We substitute in the second equation.

T: We consider BODMAS do you remember? (Spoken as: *Re considara BODMAS le a gopola?*) [BODMAS, the acronym used for the order of calculation of fractions, stands for Bracket; Of; Division; Multiplication; Addition and Subtraction]

[Part 2]

Subsequently, Mr Timba wrote the following equation on the board having substituted the value of x for y in the second equation.

$$2(\frac{4y+7}{3})^2+(\frac{4y+7}{3})y+3y^2=4$$

He then asked the class:

T: How do we do it? (Spoken as: *Re etsa bjang?)*

L: A few learners answered as follows:

$$2(\frac{4y+7}{3})(\frac{4y+7}{3})+\frac{4y^2+7}{3}+3y^2=4$$

L: Ohhh... (One learner said)

[Part 3]

Mr Timba continued the lesson, leaving the class to solve the two equations.

T: I want us to remove the brackets [*the teacher referred to the product that follows*]

$(4y+7)(4y+7)$

L: We multiply the expression, said one learner

T: Do we have an expression?

L: Term

The teacher wrote on the board:

$$\frac{32y^2+112y+98}{9}+\frac{4y^2+7y}{3}+\frac{3y^2}{1}=4$$

$$9(\frac{32y^2+112y+98}{9})+3(\frac{4y^2+7y}{9})+\frac{9.3y^2}{9}=4$$

$$32y^2+112y+98+12y^2+21y+27y^2=36$$

$$71y^2+133y+62=0$$

The students were quiet during this time and no questions were asked.

[Part 4]

The lesson continued as follows:

T: What are we determining? How are we getting it?

L: (One learner answers) Quadratic formula.

T: Do you know quadratic formula? I doubt.

L: (in chorus), Yes we know it (Spoken as: *Ja, ra itse)*

T: I am going to ask each one of you. Do you know? (The teacher pointed a chalk at the board for one minute waiting for learners to respond so that he could write the formula. You wrote it in the assignment. Have you forgotten it? Don't you know? Have you forgotten it? Let me hear you. Do you also know it? Have you also forgotten? (Spoken as: *Ke ilo botsisa yo mongwe le yo mogwe. Wa itse.... O e lebetse? Ga o itse. O e lebetse?. Tla ke go utlwe. O a itse wena? Le wena o lebetse?)* As he was asking the learners he also pointed at them counting... 4, 5, 6, etc...).

T: Do you know? You are looking at the book. Tell me what is it?

L: long pause... $x = y$ ...

T: Shut up, you will soon catch cold. (I think the teacher is teasing the learner because he realised that she was not going to give the right answer).

Finally, another learner gave the quadratic formula.

$$x = \frac{-b \pm \sqrt{b^2} - 4ac}{2a}$$

T: Is it complete? Is this a quadratic formula? Are you seeing it for the first time? (Spoken as: *E feletse. Ke quadratic formula ye Ke lanhla le e bona?)*

T: This is standard 2 (Grade 4) work. *(Spoken as: Ke mmereko wa standard 2. Le tla re ha ke le phasisa la re ke a le hlolla).*

(I am not sure what he meant. I guess he meant that, because the work is so easy if they pass they will think that it is unfair.)

For about six minutes, the teacher was asking this kind of questions without waiting for a response from the students. It was the end of the period. The teacher told the learners to finish substitution to solve for y in equation $71y^2 + 133y + 62$ using the quadratic formula.

4.1.1.1 Comments from field notes

This problem was the only one done during this lesson and it was not completed. I felt that little work had been done during this period. I also felt that a lot of time was spent by Mr. Timba asking unproductive questions which were directed to learners recalling the quadratic formula. After the lesson, as I was talking to the teacher, he said that the learners have a problem of recalling the formula. (I did not ask him anything about the lesson because my role as an observer was not to suggest anything at that stage). Mr. Timba said that he drilled the formula yet they still could not recall it. He also said that he derived the formula in class with them and also applied it in solving problems. He said that the standard grade learners were not supposed to know how to derive the formula. However, the standard grade and higher-grade learners were taught in the same class. When there were sections that applied to the higher grade, Mr. Timba would mention this during the teaching. The problem solved during this period was one of the problems that were given as a group assessment. In this case, the learners were given three problems which were marked out of 30. A group of five or six learners write one assignment and each learner gets a group mark.

4.1.2 Analysis of the lesson

4.1.2.1 Content

The lesson on simultaneous equations was conducted in a didactic manner because *the structure of the content was in the form of factual content and factoids (STAM 1A).* The content on the topic of simultaneous equations was presented following steps that were geared to learners reproducing knowledge in the form of facts. There were no descriptions or explanations of concepts in this lesson. In parts 1 and 4, we see how Mr. Timba also asked questions that would lead to reproduction of a formula.

Similarly, there were *no examples or connections to (a) real world events, (b) related ideas or (c) key ideas of the subject (STAM 2A).* Parts 1-4 of the lesson description show how the solution of the simultaneous equation was obtained. This concept was presented in the form of facts that followed steps leading to a single form of problem solution, namely the quadratic formula.

In a like manner, *the limits, exceptions, and multiple interpretations were oversimplified so that the limits or exceptions within the content were not presented. Many statements are absolutes without qualifiers (STAM 3A).* In this lesson on simultaneous equations, there were no uses of multiple interpretations of content. The concept of simultaneous equations was presented as absolute facts without qualifiers. Only one form of interpretation was used. For example, the solution of the two equations was presented in a way that required a solution using the quadratic formula as the only method. This concept was not integrated within other forms of knowledge, as can be seen in Parts 1-4.

There was no discussion of processes and history of mathematics. The mathematical method was presented separately in an algorithmic approach (STAM 4A). In this lesson on simultaneous equations, the teacher as seen in Parts 1-4, presented this concept using a procedure that was leading learners towards particular steps of solving the problems without eliciting questions on 'how we know'. The solution of the equation according to the teacher's approach was geared towards being solved using the quadratic formula. The teacher presented the concept of simultaneous equations using one method.

4.1.2.2 Teacher's actions and assessment

This lesson was taught in a didactic manner because *one or two teaching teacher-centred methods predominated (STAM 5A).* Based on the description of the lesson in Parts 1 and 2, this teacher-centred method predominated. The description on simultaneous equation shows that the teacher used the question and answer method while solving the problem to lead learners to tell him what was supposed to be done to solve this problem. The students gave no responses to the teacher that enabled him to judge their progress in learning about simultaneous equations.

Similarly, the lesson was didactic in nature because *demonstrations, labs, and hands-on activities were not used (STAM 6A).* Based on the observations and descriptions of this lesson, instructional activities that involved labs, demonstrations and hands-on activities were not present in this lesson.

However, there was some *teacher-student interaction about subject matter even though this involved 'Chalk and talk' (STAM 7AB).* This small portion of the lesson would appear to be an attempt towards transitional teaching because, as shown in parts 2 and part 4 of the lesson, there was an attempt to generate teacher-student interaction but this did not lead to any cognitive outcomes on behalf of any of the students. The teacher used the question and answer method to interact with the students; this interaction involved the teacher drawing the students towards correcting their ideas, as is characteristic of transitional teaching.

This lesson on simultaneous equations also was didactic because the *teacher's questions called for factual recall (STAM 8A).* The excerpt in Part 4 showed that the teacher's questions required learners to recall factual knowledge, in this case asking students if they had forgotten the quadratic equation formula. The amount of time in the lesson that the teacher used to elicit the quadratic formula from the learners also indicated the extent to which the teacher regards the importance of learners recalling the formula.

Based on the description of the lesson on simultaneous equations, Mr. Timba used group work assessment. Discussions with the teacher following the lesson indicated that *tests were used for assessment (STAM 9A).* No quizzes were used that might have given students and the teachers, formative feedback about their work. Moreover, the lesson is didactic in nature because there were no *uses of assessment beyond grading (STAM 10A).*

The lesson also was characterised as didactic because the *teacher disregarded students' ideas about subject matter (STAM 11AB).* In terms of the teacher's response to student ideas in this lesson on simultaneous equations, Mr. Timba, implicitly accepted students' responses when they responded to questions that were posed in the process of solving for x and y but he did not solicit the students' questions. In this sense, the teachers' questions in terms of STAM may be moving towards transitional teaching. This can be seen in the discussion in Parts 1 and 2.

4.1.2.3 Students' actions

Similarly, the lesson was classified as didactic because *writing and other representations of ideas were not used, only short answers from students predominated (STAM 12A).* A closer look at the lesson on simultaneous equations as described above, shows that the kind of writing that students did in the lesson was to write the solution of the problem as it was solved on the chalkboard and to complete the solution for y on their own as requested by the teacher at the end of the lesson.

No other representations of ideas were used. Only students' short answers predominated Parts 1 and 2 of the lesson.

In a like manner, the lesson was didactic because there were *few students' questions (STAM 13A).* The scenario depicted in the lesson on simultaneous equations showed the kind of interaction that took place during the lesson proceedings. From this record the students asked no questions. The teacher asked all the questions. Moreover the lesson is didactic in nature because *student–student interaction was rare/nonexistent (STAM 14A).* As can be seen in the lesson proceedings the only interaction was between the teacher and the students as a group.

Also, the lesson on simultaneous equations was didactic because *students rarely volunteered examples or analysis (STAM 15A)* or assisted in the analysis of simultaneous equations, as shown by the kind of interaction that took place in all parts of the lesson. The teacher, Mr. Timba, used the questioning approach to lead learners to tell him what was supposed to be done to solve the problem. Looking at the lesson description, students never volunteered examples or analysis. The teacher came up with the example that was discussed.

In terms of the descriptions of the lesson on simultaneous equations provided in the beginning of this discussion in Mr. Timba's classroom, the students *accepted the teacher's procedures* without questioning them, which is typical of didactic teaching *(STAM 16C).*

4.1.2.4 Resources and environment

The lesson on simultaneous equation is didactic because available resources were only the chalkboard and chalk *(STAM 17A).* In this class, there were not enough chairs for all the students. Some learners were standing throughout the lesson.

Similarly, the nature of the lesson was didactic because *students looked at, but did not actively use resources (STAM 18A).* There were no resources beyond the teacher's textbook, chalkboard, the learners' notebooks and the chalk. In a like manner, *access to resources was controlled by the teacher (STAM 19A)* and the *locus* *of decision-making was teacher dominated (STAM 20A).* The teacher decided on the lesson proceedings, and in this lesson he worked out one of the problem that was given as an assignment. *Few teaching aids were displayed and so none were integrated with content (STAM 21A).* Finally, the lesson was didactic because there was *no student's work displayed during this lesson on simultaneous equations* (*STAM* 22A).

4.1.2.5 Summary

In this lesson on simultaneous equations, a description of the lesson was given followed by an analysis of the examples from the lesson guided by STAM descriptors discussed in Chapter 3. Out of the 22 STAM descriptors, it was found that this lesson was didactic. However, with respect to the descriptors teacher-student interaction *(STAM 7AB)* and teacher's responses to students' ideas *(STAM 11AB)*, the lesson showed several minimal attributes of transitional teaching.

4.2 Changing the subject of the formula

4.2.1 Description of the lesson (Kt2/100501/Gr10)

In this lesson, the teacher, Ms Mogotse, was correcting homework. She wrote four problems on changing the subject of the formula on the chalkboard and asked one learner to write the answer to the first problem on the chalkboard.

(a) $T = a + (n-1)d,\ n =$

(b) $S = \frac{1}{2}gt^2,\ t =$

(c) $A = \pi r^2,\ r =$

(d) $V = lbh,\ b =$

However, the learner came to the board but did not appear to have completed the homework that was to change the equations to the given subject. Whilst waiting for the learner to come forward, the teacher and the learner had this interchange:

[Part 1]

T: You cannot learn if you did not do the homework

L: I did not understand

T: Did you ask anybody?

L: silent

The teacher asked another learner to come forward to do the homework. On this occasion, the learner attempted the problem but had difficulty completing the work. The teacher then took the chalk and started to work out the problem, at the time she was grumbling saying, "Most of you did not do this."

Subsequently, Ms Mogotse worked out the problem on the chalkboard which was to make n the subject of the formula given $T = a + (n-1)d$. As she explained "I want n to be on the left hand side; take it one by one. What you do on the left, do on the right."

L: OK (said the learners in a group).

[Part 2]

The following is what Ms Mogotse wrote on the chalkboard

$$T = a + (n-1)d$$

$$a + (n-1)d = T$$

She explained that $3 = a$ is the same as $a = 3$. *This was the emphasis made for writing the term with the required value on the right hand side.*)

$$\frac{(n-1)d}{d} = \frac{T-a}{d}$$

$$(n-1) = \frac{T-a}{d}$$

$$n = \frac{T-a}{d} + 1$$

One of the learners that I sat next to did not know that he was to solve for n. Another learner thought that $T = (n-1)a + d$ was the same as the sum above $T = a + (n-1)d$.

Comment: *I did not know whether they got the sum right or wrong, the teacher did not find out from learners, she did not find out what their problems were. I also thought that leaving out a step would lose them.*

Ms Mogotse then told the students to do the next problem in their scrapbooks. Again, Ms Mogotse asked another learner to come forward and work out the problem on the chalkboard. However, without waiting more than one minute for the student to respond, she worked out the problem on the board as follows:

$$A = \pi r^2, \quad r =$$

$$\frac{\pi r^2}{\pi} = \frac{A}{\pi}$$

$(r^2)\frac{1}{2} \leftarrow = \left(\frac{A}{\pi}\right)\frac{1}{2} \leftarrow$ used coloured chalk to show the exponent

Again Ms Mogotse explained this way by referring to some previous work — $(a)^{1/2} = \sqrt{a}$

$$r = \sqrt{\frac{A}{\pi}}$$

Throughout the solving of the problem on the chalkboard, no students were asked to contribute.

[Part 3]

T: From here I am going to give you class-work.

$S = \frac{1}{2}gt^2$, make t the subject of the formula.

T: What is the answer? Someone come and write on the board. (*I think this invitation was because they were still working on homework corrections*)

L: A learner stood up and wrote on the chalkboard:

$$\frac{\frac{1}{2}gt^2}{\frac{1}{2}g} = \frac{S}{\frac{1}{2}g}$$

$$t^2 = \frac{S}{\frac{1}{2}g}$$

At this point the learner got stuck and could not continue.

When the learner got stuck the teacher asked

$\frac{S}{\frac{1}{2}g}$ Equals what?

[Part 4]

T: You just wrote a long thing (*I think she means the learner just wasted time*); at the end you did not solve for *t*. Then Ms Mogotse worked out the problem as follows continuing from the learner's work

T: Don't change big letters to small letters.

$$t^2 = \frac{S}{\frac{1}{2}} g$$

$\frac{S}{\frac{1}{2} g}$ Equals what, said the teacher? Is 2s this is a division.

$$S \div \tfrac{1}{2} \rightarrow S \times 2$$

$$= 2S$$

$$t^2 = \frac{2S}{g}$$

$$t = \sqrt{\frac{2S}{g}}$$

4.2.1.1 Comments from field notes

As she worked out the problems, the learners copied them in their notebooks. Ms Mogotse gave out class work involving more problems on changing the subject of the formula. During the second period of a double period, she wrote six more problems on the chalkboard but I did not copy them down. After a learner asked what page the work came from, she wrote Page 63 on the chalkboard. However, I also noticed that few learners had textbooks with them. The rest of the period was spent by most learners doing work on their own. I observed that the teacher, Ms Mogotse, helped a few learners who were sitting in front. The learner that I was sitting next to wrote the following for changing the subject formula to *r* in the formula: $e = \frac{E}{R + r}$

$$\frac{R \times E}{R + r} = e$$

$$\frac{r \times E}{r} = \frac{e}{r}$$

$$r = \frac{e - R}{E}$$

(This problem was copied from the learner's book)

All the other problems of these learners that I sat close to were also wrong. More information would be found through checking learners' homework and class workbooks. These problems were not followed up.

Comment: *I felt that much could have been achieved if these problems were discussed in class on the chalkboard.*

I thought that the learners would have benefited much through thought-provoking questions and interactions, as for example asking or reflecting metacognitively and so students being consciously aware of themselves as problem solvers, and to monitor and control their mental processing. Basic metacognitive skills are how can I do this?, Did it work?, How am I doing? Does this make sense? (Bruer, 1993, p. 67).

I also noticed that there were two learners who spend the period sleeping on their desks but the teacher did not pay attention to them. I noticed that Ms Mogotse did not check whether or not learners did their homework or inquired whether or not they had difficulties with their work. During the lesson, the teacher was continually moving out of the class. She told me later on that she went to tell the learners in the neighbouring class to keep quiet because they were noisy as their teacher was absent.

4.2.2 Analysis of the lesson

4.2.2.1 Content

The lesson on changing the subject of a formula was largely conducted in a didactic fashion because the *structure of the content was in the form of factual content and factoids (STAM 1A).* In the description of this lesson's proceedings, learners who were called to do the problem on the chalkboard could not get the answer right. On one occasion a learner excused himself from doing the problem on the chalkboard. Subsequently, the teacher worked out the problem on the chalkboard as seen in Parts 2 and 3. Looking at the teacher's chalkboard writing, one can infer that the teacher's approach is factual. There are neither descriptions nor explanations of facts. Perhaps that is why the learners were not able to get the problems right.

In the same way, there were *no examples or interconnections to (a) real world events, (b) related ideas, or (c) key ideas of the subject (STAM 2A).* The sample examples that were worked out in this lesson on changing the subject of the formula, [see indented section] indicate that these examples are not interconnected to real world events, related ideas or key ideas of the subject. The examples are only for the purpose of teaching the method of changing a formula from one form to another.

In addition, the content that has been used in the topic of changing the subject of the formula is presented as pure *statements without qualifiers (STAM 3A).* This can be seen in the kind of exercises and solutions that was given in this lesson, for example $T = a + (n-1)d$, $n = \frac{T - a + d}{d}$ other interpretations were presented nor integrated with other content.

In the same way, there was no discussion of the *processes and history of mathematics and no explicit mention of how we know. Mathematical method was presented separately as an algorithmic approach (STAM 4A).* The method of the presentation of the content in examples of changing the subject of the formula was in the form of learners following the procedures as put forward by the teacher without questioning. In this example, learners were called to come and work out problems on the chalkboard and could not complete the problem. A presumption could be made that this was caused by the presentation of content as rote procedures with no mention of how we know (mathematical reasoning).

4.2.2.2 Teachers' actions and assessment

The lesson on changing the subject of the formula was primarily didactic because only *one or two teacher–centred methods predominated (STAM 5A).* As seen in the lesson description, learners who were called to do the problems on the board could not solve them. The teacher, Ms Mogotse, then worked out these problems without questioning the students at all [Part 2 and Part 4]. There was no interaction of the teacher with the learners. Only one teacher-centred method predominated.

In the same way, the lesson was didactic in nature because *demonstrations, labs and hands-on activities were rare (STAM 6A).* The activities in this lesson involved the teacher asking learners to work out homework problems on the chalkboard, for example changing the subject $A = \pi r^2$ to r and $T = a + (n-1)d$ to n. The teacher invited learners to work out these problems on the chalkboard but allowed very little time for them to do so. The teacher then worked out these problems after learners failed to do them. Other activities involved learners writing down corrected problems in their notebooks without any exploration being given by the teacher. When all the homework problems were worked out, during the rest of the period, learners were given more problems relating to changing the subject of a formula. The description of the lesson on changing the subject of the formula shows what transpired in this lesson; no hands-on activities were used.

In like manner, there was *little teacher-student interaction about the subject matter (chalk and talk)(STAM 7A).* In this lesson, when the teacher corrected homework on problems involving changing the subject of a formula, one of the lesson activities was to invite learners to work out problems on the chalkboard. It was observed that in all the cases, learners who went to the board had difficulty during the process of working out these problems and were not assured to solve the problem by the teacher. Part 1, 3 and 4 of the lesson shows the kind of teacher-student interaction that took place in this class. There were no teacher-student interactions about the subject matter; that is, there were no interactions concerning the learners' specific difficulties about the subject matter.

Besides, the lesson was didactic because the *teacher's questions called for recall of facts (STAM 8A).* The excerpt in Part 4 of the lesson on changing the subject of the formula illustrates the kind of questions that were asked by the teacher. These questions were for directing lesson procedures without clearly explaining the process of changing the subject of the formula. Although there were no questions that were directed to recall facts, learners were expected to recall previously learning, for example that $3 = a$ was the same as $a = 3$.

In the same way, the nature of the lesson was didactic because *assessment was in the form of tests and quizzes only (STAM 9A).* The kind of assessment involved assignments and tests to find out whether learners were able to change the subject of a formula to another required subject. For example, given $S = \frac{1}{2}gt^2$, students were asked to make t the subject of the formula. In the lesson, no quizzes were used as a form of assessment in the observed lesson. However, Ms Mogotse told me that she would assess the students learning on the topic by a test in the next week.

Again, the lesson on changing the subject of the formula was didactic because there was *no use of assessment beyond grading (STAM 10A).* As mentioned in the examples (See Parts 1-4), when the learners could not solve the problems given, the teacher worked out the problems on the chalkboard for them without checking on specific difficulties that the learners encountered when solving those problems. At this part in the lesson no grades were given.

Moreover, the didactic nature of the lesson was because *the teacher disregarded students' ideas or did not solicit students' ideas (STAM 11A).* A closer look at the description in the lesson shows that students who were asked to do problems on the chalkboard and others in the class did not come up with any suggestions or questions about the manipulation techniques of the problems that they were trying to solve. All the ideas concerning the lesson came from the teacher.

4.2.2.3 Students' actions

Another reason for the lesson to be primarily didactic was because *writing and other representations of ideas were not used (STAM 12AB).* Following the description of the lesson on changing the subject of the formula above, when learners could not do the problems, Ms Mogotse worked them out as indicated in Parts 2 and 4. The writing that learners did was to copy down these problems into their notebooks and also write during class work and homework problems. No other writings and representations of ideas were used. These writings required students to rewrite equations with a change of subject, such as shown in Part 2 of the lesson. However, these reconfigurations of the information provided are typical of transitional teaching.

Parts 1-3 shows what transpired in an interchange between the teacher and the learners. From the record of the lesson, *students did not ask any questions in this* *lesson (STAM 13A).* Another reason for the lesson to be classified as didactic was because there were *no student-student interactions (STAM 14A).* As the teacher worked out the problems, the learners were copying them into their notebooks. Based on the descriptions provided above, student-student interactions were non-existent.

Students did not volunteer examples or analysis (STAM 15A). As described in the beginning section of the lesson, the teacher invited learners to come to the board and work out problems. Students did not volunteer/initiate activities or do additional examples to those provided by the teacher for homework and class work. The only examples attempted were those given by the teacher and the students were not able to work them out.

I observed that in the lesson on changing the subject of the formula, the *students accepted the procedures given by the teacher, and did not question them (STAM 16C).*

4.2.2.4 Resources and environment

Furthermore, the lesson was didactic because *only the text was used in this lesson (STAM 17A).* The teacher, Ms Mogotse, solved problems that were copied from a textbook onto the chalkboard. Subsequently, learners wrote the problems in their notebooks. Similarly, the lesson was didactic because *students did not actively use resources (STAM 18A).* In this lesson, there were no resources for hands-on activities beyond the learners' pens and books. The only resources available were the chalkboard and the learner notebooks. Most learners did not have mathematics textbooks with them. The teacher copied examples for learners from her teacher's copy. Likewise, the lesson is characterised as didactic because *access to resources, in the case of textbooks, was controlled by the teacher (STAM 19A).*

What's more, the lesson is typical of a didactic lesson because the *locus of decision-making was teacher dominated (STAM 20A).* There was no sharing of decisions with the students. The teacher made all the decisions. This was also seen in this example were the teacher invited more learners to come to the board and then also showed them how the problems were to be solved. The learners made no decisions about which problems were to be chosen for homework or class work.

Also, the lesson was didactic in nature because *few teaching aids were displayed (see STAM 21A)*, other than the teacher using the chalkboard. In addition, *no examples of students' work were displayed (STAM 22A).*

4.2.2.5 Summary

This section presented an analysis of the lesson on changing the subject of the formula using the 22 STAM descriptors. Firstly, a description of the lesson was given followed by an analysis of the lesson. The lesson according to the evidence given was found to be didactic in terms of all the STAM descriptors except in terms of *STAM 12AB*, writing and other representations of ideas, when the lesson was transitional even though this was minimal.

4.3 Compound interest and depreciation

4.3.1 Description of the lesson (Tt3/290501/Gr12)

In this class, the problems were on calculating the compound interest and depreciation --the topic was introduced as interest and depreciation. I observed that learners were seated in groups; there were seven groups, four groups of four, one group of five, one group of seven and one other group of two. I noticed that there was on average one calculator per group, but one group did not have a calculator.

[Part 1]

The problem on compound interest regarding South African Rands was written as follows:

> R1000 amounts to R1500 after $2\frac{1}{2}$ years. The interest was calculated monthly. Calculate the rate of interest per year.

The teacher, Ms Makola, wrote the formula on the board and demonstrated using the calculator how to key in the values as in the following example. She borrowed a calculator from one learner and showed the class which buttons to press. As she explained, she said:

T: Do not forget the BODMAS rule. Use your calculator.

T: Is there anyone who calculated the rate of interest?

L: No (said learners)

The teacher wrote this work on the chalkboard:

$$A = P(1 + \frac{r}{100})n$$

$$r = 100(\sqrt[n]{\frac{A}{p}} - 1)$$

$$r = 100(\sqrt[30]{\frac{1000}{1500}}) - 1$$

T: Firstly do [the mathematics] [the root sign, that is] inside $\frac{1000}{1500}$

T: Give me the answer (Spoken as: *Mphe answer ya*)

L: 0,000…? [In South Africa, the decimal point is written as a comma, i.e. 0.000 is written as 0,000]

Another learner said

L: 15, …(the rest of the learners kept silent)

However, some learners discovered that there was a mistake in the working above and alerted the teacher.

[Part 2]

Ms Makola then wrote on the chalkboard.

$$r = 100\left[(\sqrt[30]{\frac{1500}{1000}}) - 1\right]$$

$$r \quad = 100\ [(\sqrt[30]{\ }\ 1{,}5) - 1]$$

$$r = 100\ [(1{,}013607 - 1]$$

$$r \quad = 100\ [(0{,}0136073)]$$

$$r \quad = 1{,}36073$$

The large bracket was not written on the chalkboard, I have shown it here to clarify the expression. As Ms Makola wrote she was looking at a paper that was stuck into a textbook. During this lesson, Ms Makola did not explain were the 30^{th} root came from, but continued as follows:

T: The answer is the amount per month. To get the interest per year, multiply by 12, that is 12 x 1,36073 = 16,33 %, after rounding it off.

Ms Makola then moved from one group to another showing learners how to key in the values. For each group, she calculated whilst they watched. It seemed as though the learners did not know what to do or which buttons to press. Most of the learners did not have their own calculators. During the lesson, they were copying from the board or watching the teacher demonstrate with a learner's calculator.

T: The manual that you get with the calculator, do not throw it away. Is there a question on calculating the rate of interest? (Spoken as: *Manual o le o kereyang don't throw it away. Go na le question of calculating the rate of interest?*)
L: No (some learners)
T: The only difficulty you have is using the calculator.

[Part 3]

The next topic by Ms Makola was as follows:
T: Depreciation, coming from the word depreciate. What does it mean? She added, to be reduced.
The formula for depreciation was given as $A = P(1-r)^n$. Ms Makola alerted the learners that the difference with the first one was with the sign. The problem given was:

> A high quality car cost R18300 and depreciates by 8% annually. Calculate what the car will be worth after 5 years.

The bell rung to mark the end of the period but Ms Makola continued with the lesson. Learners were led to give the values as follows, which were written on the chalkboard:

$A = ?$
$P = \text{R}18300$
$r = 8\%$
$n = 5\text{yrs}$

Learners were working on their own to write down this problem. Eventually, they were sitting in groups but there was no evidence of their working together. As before, the teacher helped some of the learners in their groups by calculating the solution to the problem while they watched.

T: Did you get the answer? (Spoken as: *Le kereile answer?*)

L: I am not sure. (Spoken as: *A ke sure*)

This problem was not worked out on the chalkboard. The teacher gave the answer verbally and proceeded to the next piece of work.

[Part 4]

The next problem was written as portfolio-assessed work. In this teaching situation, the teacher gave learners 15 minutes to complete the work that they were to do in groups. Assessment was through group marking. The problem was:

> Factory machinery depreciates at 10% per year. What will R10000 of Machinery be worth in 5years time?

Some learners were busy writing while others were walking, standing and talking with friends. In one group, two girls were working with a calculator while two boys stood watching. From the look of things, only one learner was doing the work. When they finished the students gave the piece of paper to the teacher who said:

T: I am not going to mark you now. Completion time is important. (Spoken as: *Ga ko le maka gona bjale. Completion time e bohlokwa*)

They wrote the work on a piece of paper. Ms Makola told the learners to write their names on the paper and also to hand in all their previous marks and tests scripts for their files. At the end of the period she collected all the written scripts. One group finished after the rest and she told them to put their script on her table.

4.3.1.1 Comments from field notes

At the beginning of the lesson, there was no spare chair for me to sit on and I opted to sit on top of the desk. The teacher then asked one learner to give me a chair and the learners sat on his bookcase. The learners have a two quire or three quire notebooks wherein they write all their notes in class because they do not bring textbooks. There were no pictures on the wall.

4.3.2 Analysis of the lesson

4.3.2.1 Content

The lesson on compound interest was primarily conducted in a didactic manner because *the structure of the content was in the form of factual content and factoids (STAM 1A).* The description of the lesson shows the concepts introduced in the form of using formulas to calculate the required values. The fact that there was a mistake in the substitution of the values shows that emphasis was not placed on descriptions of the concepts and explanation of what the concepts are but on steps that are followed disregarding the key ideas of the concept.

Similarly, the lesson described in Parts 1 and 2 has an example of compound interest and depreciation but these concepts were not elaborated in any way to show their relevance to the students' lives. In the presentation of the content of these concepts in this lesson, *no connections to real world events, related ideas or key ideas of the subject were made (STAM 2A).* The lesson was focused more on demonstrating how to use the calculator.

When Ms Makola was presenting the content in the lesson on compound interest and depreciation, she concentrated on procedures to find the answer. Her emphasis on helping learners to key in values in the calculator shows that only *one form of interpretation of the content was used (STAM 3A).* This content was presented as absolute facts [See Parts 1 and 2]. There was no integration of the content with other content in mathematics.

This lesson was characterised by presentation of content using examples of interest and depreciation [Part 1 & 2]. However the teacher presented the concept in the form of emphasis on algorithmic approach as for example 'Do not forget the BODMAS rule. Use your calculator'. When showing learners how to key in values to calculate the rate of interest, learners were following the *teacher's procedures without reasoning 'how we know'* (STAM 4A).

4.3.2.2 Teacher's actions and assessment

The lesson was classified as didactic because *one or two teacher-centred methods predominated (STAM 5AB).* The lesson described above shows that the teacher attempted to use group work as part of her teaching. However, even though the learners were seated in groups, the classroom activities were still dominated by the teacher. Ms Makola also used the telling method in her attempt to use hands-on activities in the form of demonstrating how to use the calculator.

In the same way, the lesson was identified as didactic because there were few *demonstrations labs and hands-on activities (STAM 6AB)* but there was some indication that the lesson was transitional. For the introductory section of the lesson, the kind of seating of learners in this class and the number of calculators per group were described. Calculations in this problem as in Part 2 involved the teacher moving from one group to another showing learners how to use the calculator during calculations. In the lesson activities, the teacher demonstrated which buttons to press in calculations, and involved some attempts at hands-on activity with a few learners; according to *STAM (6AB)* this part of the lesson is showing a minimal move towards a transitional approach. The description of the lesson, however, showed that in this class the demonstrations were overly directed 'cookbook' type.

Following the descriptions of the lesson processes, Part 2 and 3 of the lesson showed that there was a *very limited kind of interaction that took place between the teacher and the student (STAM 7A).* Further, the teacher's questioning approach to the lesson, in Part 2 especially, showed that her *questions were directed towards recall of facts (STAM 8A).* Assessment was related to learners' demonstration of knowledge of how to calculate interest and depreciation in the *form of tests and group assignments (STAM 9A).* No quizzes were used in the observed lessons.

As far as the observed lesson on compound interest and depreciation was concerned, there was *no use of assessment beyond grading (STAM 10A)* and in this lesson there were *no ideas* suggested about the lesson from the learners *(STAM 11A).* All the examples and proceedings were the teacher's choice.

4.3.2.3 Students' actions

The writing done in this class was about problems on compound interest, depreciation and portfolio work [Parts 1, 4 & 5]. *Other representations of ideas were not used. Short answers predominated* (*STAM 12AB*). Nevertheless, the writings were reconfigurations of information provided, typical of transitional teaching.

The interactions as recorded in the lesson in Parts, 2, 3 and 4 shows that *there were few student questions in this lesson (STAM 13A).* The teacher was the one talking all the time, showing learners how to do calculations. There were no student questions clarifying procedures, there were no questions asking for clarification of terminology or requests to repeat information in this lesson. It has also been noted that the few students' questions that were asked did not focus on clarification of meaning related to specific concepts or procedures.

The introductory section of this lesson on compound interest and depreciation showed that learners were seated in groups but, as observed, *there was little student-student interaction (STAM 14A).* This was also seen in the lesson proceedings as reflected in Part 4 of the lesson. Part 5 also showed that only a few learners responded to the teacher's questions, and *the students volunteered no examples (STAM 15A).* The teacher gave all the examples. In this lesson, the learners *accepted what ever the teacher told them to do without questioning* (*STAM 16A*).

4.3.2.4 Resources and environment

The resources available during this lesson were the chalkboard and the chalk. During the demonstration of a calculation, the teacher had to borrow a calculator from a learner. There were *few resources beyond single text or format (STAM 17A).* However, the *students looked at but did not actively use the calculators* (*STAM 18A).* In terms of the use of calculators in this lesson, many students did not have calculators. Rather, they watched the teacher and their fellow learners doing calculations. Further, the *access to resources was controlled by the teacher* (*STAM 19A*). *The locus of decision-making in terms of learning was teacher dominated* (*STAM 20A*) with the teacher deciding which examples to give. In this class, the teacher gave the learners more work after the period ended without consulting or explaining carefully what they were to do. *There was no teaching aid displayed during this lesson (STAM 21A) and no students' work was displayed* (*STAM 22A*).

4.3.2.5 Summary

In this lesson on compound interest and depreciation, a description of the lesson was given followed by an analysis of the examples from the lesson guided by the STAM descriptors discussed in Chapter 3. Out of the 22 STAM descriptors, all the descriptors identified the lessons as didactic. In terms of *STAM 6AB* and *STAM 12AB*, there were indication of move towards transitional teaching, but this was still minimal. These are parts of the lesson in which the teacher attempted to use calculators in demonstrating how to do calculations.

4.4 Limits of functions

4.4.1 Description of the lesson (Tt4/290501/Gr11)

Learners were in rows on desks that seated two students. The teacher, Mr. Mosotho, was teaching limits of functions. He worked out one homework problem on the chalkboard using the question and answer method to elicit responses from learners, writing the following on the board.

[Part 1]

$$f(x) = 2x - 1$$

$$f(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$$

$$= \frac{2(x+h) - 1 - 2x - 1}{h}$$

$$= \frac{2x + 2h - 1 - 2x - 1}{h}$$

$$= \frac{2h - 2}{h}$$

He left the answer like that without providing any verbal explanation of what he was doing.

[Part 2]

Then Mr. Mosotho asked a learner to do the next problem $f(x) = 3x - 7$ on the chalkboard. The learner just wrote the formula but could not do the problem. Without speaking, he wrote:

$$f(x) = \lim_{h \to 0} \frac{(x+h) - f(x)}{h}$$

However, the learner got stuck and could not do the next step.

T: You did not do anything. That is only the formula (Spoken as: *Hape ha oa ira selo. Ke formula).*

The teacher then took over and wrote on the chalkboard:

$$f(x) = \frac{3(x+h) - 7 - (3x - 7)}{h}$$

T: What does it give us?

Without waiting for a response from the student, he wrote:

$$= \frac{3x + 3h - 7 - 3x + 7}{h}$$

T: We remain with?

$$= \frac{3h}{h}$$

$$= 3$$

At no time was an explanation given for solving this problem.

[Part 3]

Then Mr Mosotho wrote three problems for the students to complete in class during the rest of the period.

1. $f(x) = 3x - 4$
2. $f(x) = 1 - 4x$
3. $f(x) = 3x^2 - 2x + 1$

As they were writing the teacher said:

T: Write! Are you writing or are you talking? (Spoken as: *Ngwala, la ngwala goba la bolela?*)

L: Do you mean all of these problems? (some learners said) (Spoken as: *Tse tsohle?*).

T: You will regret this. Do not forget what you are doing. The majority of you will regret this. I feel pity for you. You say this class is yours and mine. Not long you will be crying. Write. Are you writing or are you talking?

(Spoken as*: Le tlo itshola, e be le itebetse, le seka itebala. Majority ya lona le tlo itshola. Ke le utlwela bohloko. A ke re le re clase ye ke ya ka le ya lona. Le tlo lla e se khale. Ngwala, la ngwala goba la bolela?)*

Many of these kinds of comments were more while learners were busy writing.

T: Are you finishing? Are you finishing? It does not seem so. What are you doing with a calculator? Don't you know 3×2? We are left with 5 minutes. (Spoken as: *La fetsa, la fetsa, mara ha ho bontshe bjale ne. Ka calculator le irang? Ha le itse* 3×2. *Ho setse 5min*).

Those who had finished writing closed their books; the teacher then took some of the books and marked them.

During the lesson, I observed that Mr. Mosotho was not helping any student. Initially, I thought that perhaps the students knew what to do. However, some learners were paging back in their books and seemed not to know how to do the problem. The rest of the time was spent with most learners writing in their books. The teacher moved to the back of the class, while learners remained quiet, there being little talking amongst the students.

T: Isn't it that you know that I will write the answers? (Spoken as: *A ke re le a itse ke ngwala diantshara?*)

Then he wrote the answers next to the problems.

1. 3
2. – 4 (initially he wrote 4 not – 4)
3. $6x-2$

Mr. Mosotho explained the last problem verbally and the learners asked him to explain all of them. While he did the problems on the board, he wrote the formula and worked out the problems and told the students that they would be writing a test the next day.

4.4.1.1. Comments from field notes

Due to the fact that a lot of issues not related to the lesson were said during the lesson, it was observed that a number of aspects of the lesson were concluded abruptly, and answers were written quickly without further clarity. Once the bell rang to signal the end of the lesson, there was a lot of disturbance such that fundamental explanations were not thoroughly done. This can result in learner difficulties that are carried over into the next lesson.

4.4.2 Analysis of the lesson

4.4.2.1 Content

The lesson on limits of functions was predominantly carried out in a didactic manner because the structure of the content is in the form of *factual content and factoids and was formula driven (STAM 1A)*. Similarly, there were *no examples or interconnections to real word events or related ideas* that the students might have known *(STAM 2A)*. In the same way, *there was only one* interpretation on the solution to the problem (*STAM 3A*) and the *mathematical method was an algorithmic approach (STAM 4A).*

4.4.2.2 Teacher's actions and assessment

The lesson on limits of functions was primarily conducted in a didactic manner because only *one or two teaching teacher-centred methods predominated (STAM 5A).* The scenario above shows that the teacher used the telling method in his approach to problem solutions of homework, with minimal use of the question and answer method [Parts 1, 2]. The dominating nature of the teacher, Mr. Mosotho, was also seen in terms of his attitude to learners in class; he said many things that did not relate to the lesson proceedings [Part 3].

There were *no hands-on activities in this class (STAM 6A)* based on the description of the lesson proceedings. As illustrated in Part 2 of the lesson, the kind of interaction that took place included *little teacher student interaction about subject matter (STAM 7A)*. Also, some of these interactions were about unrelated issues to the lesson [Part 3]. The interactions were all related to the teacher's chalk and talk.

The example in Part 2 showed that the teacher's question directed learners' thinking towards *recall of factual procedures (STAM 8A)*; they were not directed towards connections or applications of mathematical ideas. This questioning did not build on students' responses. The kinds of assessment as observed related to questions about solving limit problems in the *form of tests and group assignments (STAM 9A)*. No quizzes were used. As observed, there were *no uses of assessment beyond grading (STAM 10A)*.

The teacher, Mr. Mosotho, worked out problems, gave learners other problems for class work and worked out the problems when the learners had finished writing. There were no *suggestions for learners concerning how problems were to be solved (STAM 11A)* from the description of this lesson.

4.4.2.3 Students' actions

In the same way, the lesson was didactic because the type of writing in the class was in the form of worked out problems like in Parts 1 and 2 and the class-work problem in the beginning of Part 3. There were *no other writing and representations of ideas (STAM 12AB)* except that which involved solutions to homework and class work problems and explanations. Short answers predominated. However, most of these writings were reconfigurations of information provided typical of transitional teaching.

The description of the lesson on limits of functions as recorded indicates that there were almost *no student questions in this lesson (STAM 13A).* The teacher asked all the questions. There were no student questions clarifying procedures, nor questions asking for clarification of terminology or repeat of information. Neither was there student questions focusing on clarification of meaning related to specific concepts or procedures [Part 2].

The lesson activities involved the teacher solving homework problems on the chalkboard using the question and answer method to elicit responses from learners. Mr. Mosotho also invited a learner to come and do a problem on the board but the learner just wrote a formula and could not proceed [Part 2]. Some of the activities were working out class work on similar problems. Learners were copying down these problems. The teacher did much of the talking. Based on this example, *student-student interaction was non-existent (STAM 14A);* this was also seen in the way that learners were seated. *No activities in this lesson were initiated by the students* (*STAM 15A*), rather, the teacher initiated all the activities. S*tudents were either passive or ignored the teacher's procedures (STAM 16A).*

4.4.2.4 Resources and environment

There were no other r*esources beyond single text or format (STAM 17A)* or the chalkboard (*STAM 18A*). Further, the learners had *no say in the access of resources (STAM 19A).* In this lesson, the teacher decided upon the examples and lesson procedures ensuring that the decision-making was teacher dominating *(STAM 20A).* No *teaching aids were displayed in this lesson (STAM 21A)* and *no examples of students work was displayed (STAM 22A).*

4.4.2.5 Summary

This section presented an analysis of the lesson on limits of functions using the 22 STAM descriptors. Following the analysis of this lesson in terms of all the STAM descriptors, the lesson was mostly didactic. However, *STAM 12AB* indicated a slight move towards transitional teaching.

4.5 Geometric sequences

4.5.1 Description of lesson (Tt5/300501/Gr12)

This was an introductory lesson to the topic of geometric sequences. On entering the class, the teacher, Mr. Lekgau, wrote on the board the terms of a geometric sequence, the general formula for determining the terms of a sequence and showed the learners how to obtain each term of the sequence. I noted that learners did not have textbooks with them in class and they resorted to copying or writing notes and exercises written on the chalkboard by the teacher. As the teacher talked, the students responded in chorus by completing the sentences as he spoke.

[Part1]

T: a is the first term, r is the common ratio

$T_n = ar^{n-1}$, formula for the general terms of a geometric sequence

Mr Lekgau explained how to obtain each term in a geometric sequence

$T_1 = a$

$T_2 = ar^1$

$T_3 = ar^2$

$T_4 = ar^3$

Teacher explained, $r = \frac{T_2}{T_1}$

$r = \frac{T_3}{T_2}$

Learners were nodding as he talked.

The teacher wrote the following exercise on the chalkboard:

Determine the 5th and 8th term of the following geometric sequence 9; 3; 1...

He wrote and explained at the same time.

$$T^5 = ar^4 \qquad\qquad r = \frac{T_2}{T_1}$$

$$= 9(\frac{1}{3})^4 \qquad\qquad = \frac{3}{9}$$

$$= 9(\frac{1}{81}) \qquad\qquad = \frac{1}{3}$$

$$= \frac{9}{1} \times \frac{1}{81}$$

$$= \frac{1}{9}$$

Next he wrote,

$$T^n = ar^{n-1}$$

$T^8 = ar^{7-1}/^{8-1}$ (this was left on the board)

$$= 9(\frac{1}{3})^7$$

$= \frac{9}{1} \times (2187)$(this mistake was not discovered)

$$= \frac{1}{243}$$

[Part 2]

There was a debate on whether to write 7-1 or 8-1 as an index as shown in the solution written on the board. Mr Lekgau then explained using the formula for the nth term and ultimately wrote 8-1. Some learners after the explanation remarked that he did not tell them that it was 8-1. Some said, "we don't understand" (Spoken as: *ha re utlusise*) from their seats.

However, Mr.Lekgau did not emphasize or clarify the cause of the confusion and did not respond to the learners' question.

As he taught, Mr.Lekgau was holding a book in his hand. When he made a mistake he said it was the chalk that made a mistake. During the argument about whether to write 7-1 or 8-1, every one was shouting at the top of their voices but the teacher seemed not to mind. It seemed that the teacher was not able to control the class.

Mr. Lekgau thought that he made a mistake and then he wrote on the chalkboard:

$$T^5 = ar^{4-1}$$
$$= 9(\frac{1}{3})^3$$
$$= 9(\frac{1}{27})$$
$$= \frac{1}{3}$$

Comment: *I thought to myself that he could have written the formula first for the benefit of learners.*

Again he wrote

$$T^5 = ar^{5-1}$$
$$= 9(\frac{1}{3})^4$$
$$= 9(\frac{1}{81})$$
$$= \frac{1}{9}$$

He determined the 5^{th} term 3 times but he did not explain the cause of the confusion.

Comment: *I wondered whether learners were following. I felt that he should always write the values of a and r.*

[Part 3]

Then Mr Lekgau gave another problem.

> Determine the 4^{th} and the 6^{th} term of the following sequence: 2, 6, 18, and 54

T: How do we start? (Spoken as: *Re thoma ka ho reng?*)

Learners answered in chorus but it was difficult to hear what they said.

T: Isn't it we are all alike. (Spoken as: *A ke re ra tshwana ba bohle*)

In my opinion, this means you and I are the same, we are not different.

The teacher got the values orally from some of the learners, while others were copying as he wrote the following on the chalkboard.

$$
\begin{aligned}
T^4 &= ar^3 \\
&= 2(3)^3 \\
&= 2\times 27 \\
&= 54 \\
T^6 &= ar^5 \\
&= 2(3)^5 \\
&= 2\times 243 \\
&= 486
\end{aligned}
$$

He calculated without writing down the formula. The learners mumbled.

L: we don't understand (Spoken: *hare utlwisise).*

However, Mr. Lekgau did not address their problem. One more learner referred him back to the previous problem which was still on the chalkboard stating that he did not understand how the solution to $\frac{9}{1}\times 2187$ was found. The teacher explained about how division was done using the same example, which was still on the board. But the mistake was not erased even after the explanation.

Mr. Lekgau then moved on to the next section.

T: Now we can do simultaneous equations. We have one period (Spoken as: *Bjalong re ka etsa simultaneous equations. Re na le period e one).* The learners mumbled because it seemed they needed more examples, but they did not specifically request any. However, Mr. Lekgau acknowledged his previous error stating:

T: Correct me when I make mistakes, we have come to teach each other, isn't it so? (Spoken as: Le *mphosolle ha ke na le phoso. Re tlo rutana, a kere?*)

[Part 4]

He then continued and wrote,

Determine the geometric sequence with 2nd term $= -4$ and 5th term $= -\frac{4}{125}$

He took this problem out of a textbook but I did not see any textbook on the learners' desks. He wrote:

$$T^2 = ar^1 = -4 \ (1)$$

T: What are we given? (Spoken as: *Ba re file eng?)*

He wrote while the learners completed sentences as he talked

$$T^5 = ar^4 = \frac{4}{125} \ (2)$$

Equation $(2) \div (1)$

$$ar^4 = -\frac{4}{125}$$

$$ar^1 = -4$$

[Part 5]

T: When we divide, what do we do with the exponent? (Spoken as: *Ge re devida re irang ka exponent?*)

Some learners answered in chorus:

L: When we divide, we subtract when we multiply, we add (Spoken as:*Ha re devida ra subtract ha re multiplaya ra eda)*

One learner volunteered to do the problem on the chalkboard but failed in his attempt. Subsequently, the teacher quickly erased the learner's attempt so I could not take down what he wrote. The teacher took over and wrote the following on the chalkboard without leading the learner to think about how to do the problem.

$$r^3 = \frac{4}{125} \times -\frac{1}{4}$$

$$= -\frac{1}{125}$$

$$= 5^{-3}$$

$$r = -5$$

But the problem was incorrect.

[Part 6]

Some learners looked puzzled; they seemed not to understand why r is -5. The teacher said it was exponents. One learner seemed completely lost and asked what problem they were doing. The teacher said that it was simultaneous equations. For example, he explained as follows:

T: Simultaneous equations we combine them. When we are given two equations we use simultaneous equations. (Spoken as: *Simultaneous equations re a di kopanya. He ba re file two equations re berekisa simultaneous equations*).

T: First equation divided by second equation

This was the end of the explanation to a learner who said he did not understand what the teacher was doing. Mr. Lekgau continued with the lesson.

T: We have *r,* we want *a,* use any equation. (Spoken as: *Re na le r, re nyaka a use any equation*).

[Part 7]

He wrote

$$ar = -4$$

$$a \times -5 = -4$$

$$-5a = -4$$

At this point, Mr. Lekgau became confused and the learners helped him out.

L:(in chorus) we divide by –5 (Spoken as*: Re devida ka – 5*)

$$\frac{-5a}{-5a} = \frac{-4}{-5}$$

$$a = \frac{4}{5}$$

However, Mr. Lekgau had substituted with that wrong value of *r*.

L: Some learners said: Sir, we don't understand. Let us substitute also in equation 2. [Spoken as: *Sir ha re utlwisise a re ireng le ko (2)*]

Then Mr. Lekgau wrote,

$$a\,r^4 = \frac{4}{125}$$

$$a\,(-5)^4 = \frac{4}{125}$$

Some learners were watching.

$$\frac{625a}{625} = \frac{4}{125} \quad \div 625$$

There was one active girl who said:

L: Sir, it seems we made a mistake here. (Spoken as: *mo kare re irile mistake)*

$$a = \frac{4}{125} \times \frac{1}{625}$$

One learner said that when she worked out the answer she got 20.

L: Sir, check the answer in the textbook said, another learner (Spoken as: *Sir, lebella answer ko bukeng*).

L: Sir, we will do it later, said some.

The teacher wiped off what was written on the board and wrote again.

$$a = \frac{4}{125} \div \frac{625}{1}$$

$$= \frac{4}{125} \times 25$$

$$= 20$$

He sensed that something was not right.

Again, the teacher wrote:

$$r^3 = 5^{-3}$$

$$r = -5$$

T: The mistake is with the sign. He looked puzzled.

T: You will start it tomorrow. (Spoken as: *Le tla e thoma ka bosiu.*)

Again the teacher wrote,

$$ar = -4$$

$$\frac{1}{5}a = -4$$

Comment: *I don't know where he got* $\frac{1}{5}$.

$$\frac{1}{5}a = -4 \times 5$$

$$a = 20$$

Mr. Lekgau ignored the minus sign.

Comment: *I thought that he knew the answer was supposed to be 20.*

4.5.2 Analysis of the lesson

4.5.2.1 Content

The lesson on geometric sequence was conducted in a didactic way because also the content is presented as factual knowledge in the form of formulas, without full descriptions and explaining, for example, in the determination of the 5^{th} term and the 8^{th} term. *The content was not organised around key ideas (STAM 1A).* In this lesson, there were several mistakes [Parts 1 & 2] that happened in the presentation of the content.

A closer look at this lesson [Parts 1–4] shows that in teaching the geometric sequence, *no examples or interconnections to real world events, related ideas or key ideas of the subject were made (STAM 2A).* The examples given only related to determining the required terms of the geometric sequence.

Similarly, the description of this lesson in Part 1, the introduction of the general terms of the geometric sequence, Mr. Lekgau was working out the application of the formula. The *content was presented as pure facts 'absolutes without qualifiers' and many errors were made (STAM 3A).* In this lesson, the mathematical method was presented as 'rote procedure' but with little reflection, such as in Parts 4-7 where there were mistakes. Beginning from Parts 1-2 and the major parts of Parts 4-7 show the impact of *presenting mathematical knowledge without explicit mention of 'how we know'- reflections, on why we do things the way we do them (STAM 4A).* This impact is seen throughout the lesson where learners had gone through debates of being unsure of the correct mathematical forms. This lesson ended without any clear explanations and frustration was exhibited by both the teacher and the learners.

4.5.2.2 Teacher's actions and assessment

In this lesson, Mr Lekgau used the question and answer method to introduce the geometric sequence (STAM5A), leading much of the proceedings in this introduction [Part 1]. He also used the problem-based method since he solved problems related to geometric sequences [Part 2]. Two methods dominated this lesson.

Similarly, in this lesson on geometric sequences the teacher gave the general formula for a geometric sequence, $T_n = ar^{n-1}$, and gave examples where the formula was applied to find the required terms as shown in the lesson proceedings. During the rest of the period, the teacher worked out similar problems; *no hands-on activities were used in this lesson (STAM 6A).*

The kind of teacher – student interactions that were witnessed in this lesson were in the form of conversations that went on during problem solutions as when learners had to determine the 4th and the 6th term of the sequence: 2, 6, 18, 54 [Part 3]. This example showed that the kind of interactions that the teacher had with learners was about subject matter (chalk and talk); there were *no interactions about the correctness of students' ideas about unconnected facts (STAM 7A).* Teacher-student interactions were in the form of learners responding to the use of the question and answer method in an attempt to find the solution of problems. However, in the same way the lesson was didactic because the *teacher's questions called for factual recall (STAM 8A).* One of the problems that was to be done in this lesson was to determine the geometric sequence with 2nd term = – 4 and 5th term = $\frac{4}{125}$

Mr Lekgau took this sum out of a textbook and wrote the equations on the chalkboard [Part 5]. As shown in the example above, the kind of teacher questions called for recall of facts connected to direct application of a given formula. The questions were directed towards manipulative techniques when for example, Mr. Lekgau stated: "when we divide we subtract and when we multiply we add". However, there was no attempt to see if the learners understood what this rule meant.

In a like manner, as observed in this lesson, the kind of assessment that Mr Lekgau used was tests and assignments; there was no use of quizzes *(STAM 9A).* Besides, there were no u*ses of assessment beyond grading (STAM 10A)* and also, the *teacher-*

disregarded students' ideas about the subject matter [Part 7] *(STAM 11A).* In this lesson, learners did not make any suggestions to the lesson except for asking questions concerning how the teacher arrived at a certain calculation, as shown for example in Part 6.

4.5.2.3 Students' actions

The writings done in the class were to solve problems that related to geometric sequence as in the examples provided in Parts 1, 2 and 3 of the lesson. Short answers predominated in this lesson on geometric sequence and the writings completed were in the form of students copying out problems as they were written on the board by the teacher. No other forms of representations were given *(STAM 12A).*

Although there were more instances of students' questions than in the other observed lessons, for example, in Part 5 of the lesson there were a *few students' questions (STAM 13AB),* it was required to solve for r and some learners looked puzzled because they seemed not to understand why r is – 5. When they asked the teacher, he said that it was exponents. One learner seemed completely lost and asked the teacher what they were doing. In response, the teacher said that they were doing simultaneous equations and went on to explain to learners in a not convincing manner. This example illustrated that some student questions asked for clarification of procedures. Throughout this lesson, there were few students' questions. However, Parts 6 and 7 show the kind of questions that learners asked illustrating that this aspect of the lesson represents a move towards a transitional approach in terms of student questions according to STAM descriptors. Unfortunately, Mr Lekgau was not able to clarify their questions. The nature of the lesson was didactic because there was *no student-student interaction (STAM 14A).* Similarly, in this lesson on geometric sequences, there were no student volunteered examples or analysis *(STAM 15A).* In this example, students showed confusion on the procedures as presented by the teacher in Part 7 of the lesson *(STAM 16A).* However, this lesson showed the teacher allowing students to ask questions about the procedures that he presented. This example indicates a definite attempt at transitional forms of teaching.

4.5.2.4 Resources and environment

Resources used in this lesson were *little beyond single text or format (STAM 17A)* and there were no resources that were used, except for the learners' books and teacher's textbook *(STAM 18A)*. In a like manner, *access to resources was controlled by the teacher (STAM 19A),* who made all the decisions in the lesson *(STAM 20A)*. Similarly, *few teaching aids displayed, none were integrated with content (STAM 21A)* and no *examples of student work was displayed (STAM 22A).*

4.5.2.5 Summary

This lesson on geometric series was analysed using the STAM descriptors as explained in Chapter 3. Out of the 22 STAM descriptors, the lesson was characterised as didactic. With respect to *STAM 13AB* and *STAM 16AB*, the lesson was found to be transitional; these were the parts of the lesson were the descriptor identified the students asking questions that asked for clarification of procedures.

4.6 Trigonometry

4.6.1 Description of the lesson (Dt6/130901/Gr10)

The teacher, Mr Nare, entered the class and asked learners whether they had problems with the homework given to them the previous day. Then he wrote ten answers to questions given for homework on the chalkboard. The method that he used was to let learners copy down the answers, which were written from page 215 in the textbook as follows: Exercise 3 (a) $\theta = 49{,}3^\circ$; (b) $\beta = 30{,}5^\circ$; (c) $\alpha = 38{,}9^\circ$; (d) A = $22{,}9^\circ$ and value = 1,023, etc. and mark their homework.

Comment: *I realised that the textbook that that the teacher used did not have answers at the back. It seemed that the teacher worked out these answers himself.*

The procedure was for the students to check if their answers differed from that of the teacher. If an answer did differ, the students had to work the problem out; if they still had a different answer, they would go to the teacher. At the beginning of the period, those who did not have calculators were sent away to get them. Learners were observed moving from one desk to another trying to get help from those who had already been helped by the teacher. Only one problem out of the ten was done on the chalkboard.

Learners were seen gathering in groups talking to each other about problem solutions, some were moving from one desk to another to see how others solved problems and to get help with the operation of the calculator. Students copied answers from their peers. After getting the answer, they tried to figure out how it was found. These calculators seemed foreign to the students since most of them were borrowed.

[Part 1]

After a question from one learner who found a different answer, the teacher demonstrated how to find the answer. The problem was presented on the board as follows:

$$\frac{3\tan A}{1-\sin^2 A} \text{ If } \sec^2 A = \cot 40{,}3°$$

He wrote the trigonometric ratios

$$\cot A = \frac{1}{\tan A}$$

$$\sec A = \frac{1}{\cos A}$$

$$\cos A = \frac{1}{\sin A}$$

[Part 2]

In the following presentation to the class, Mr Nare explained how to get $\sec^2 A = \cot 40{,}3°$

T: Find the value of $x^2 + 1$ if $x = 9$

Anything to exponent $\frac{1}{2}$ is the square root of that thing

For example $9^2 + 1 = 82$

Similarly, $\sec^2(A)^{\frac{1}{2}} = (\cot 40{,}3°)^{\frac{1}{2}}$ (he inserts the $\frac{1}{2}$ exponent)

$Sec = \sqrt{(\cot 40{,}3°)}$

T: What you do on the left, you do on the right

T: The problem is the calculator.

T: The answer is 1,086

T: Who got this number? Sec A = 1,086 (Spoken as: *ke mang a e kereileng* Sec A = 1,086).

Then the teacher asked:

T: Who of you did not get this value? Raise your hands up. (Spoken as: *Ke mang a sa kereyang value e? Emisang matshoho ba le e thotseng.*)

T: Look at these steps and tell me where you did not understand? (Spoken as: *Lebella stepe tse hore ke mo kae o sa utlwisiseng*)

T: Where lies the problem?

T:I am waiting for your questions?

T: Your problem is that you use different calculators. (Spoken as: *Probleme le berekisa different calculators*)

[Part 3]

Then Mr. Nare moved from one group to another and said:

T: If you look properly here, these functions are not appearing in your calculator, that is why you are applying $\frac{1}{x}$ or x^{-1} ...if you look clearly here. (Spoken as: Ge *o ka labella pila mo*).

Then $\sec A = 1{,}086$ we invert (Spoken as: *ra inveta*)

$$\cos = \frac{1}{1{,}086}$$

$$= 0{,}920$$

$$A = 22{,}9^\circ$$

Therefore

$A = 23^\circ$ (round it off)

The final answer was worked out as follows:

$$\frac{3\tan 22{,}9^\circ}{1+\sin 22{,}9^\circ} = \frac{3\times 0{,}423}{1+0{,}152}$$

$$= \frac{1{,}269}{1{,}152}$$

$$= 1{,}102$$

[Part 4]

The teacher moved from one group to another demonstrating to some learners how to key in the values using the learners' calculators. However, learners had different models of calculators. So he suggested that learners who had the same model of calculators should work together. He explained that older versions of calculators operated differently from newer versions.

4.6.1.1 Comments from field notes

As the teacher was addressing individual learners, I felt that the learners could have benefited more from a chalkboard explanation to the whole class. These learners had different calculators, which were foreign to them because they were borrowed from friends.

4.6.2 Analysis of the lesson

4.6.2.1 Content

The lesson on trigonometric equations was primarily conducted in a didactic manner because the *structure of the content was in the form of factual content and factoids (STAM 1A).* In the introductory section of this lesson, Mr. Nare gave learners answers that were not explained. These examples show that there were no descriptions or explanations around key ideas of the content in the presentation. In a like manner, the examples given as in the introductory section did not have interconnections to real world events, related ideas or key ideas of the subject *(STAM 2A)*

Similarly, the exercises given showed those trigonometry ratios were presented as *absolute facts without relating to alternative ways of solving these problems (STAM 3A).* In this lesson, learners were sent away to look for calculators, which illustrates that the learning emphasis was on doing the calculations rather than on the mathematical concepts. Learners had difficulty in using the calculators and did not to talk about methods of doing the problem. The problem that was solved was presented using the algorithmic approach without a cognitive process. Mathematical processes were not integrated within the content *(STAM 4AB).* Rather, the content was presented as rote procedures— the fact that learners were to work out their problem according to the facts as given by the teacher. However, Mr. Nare said 'Look at these steps and tell me were you did not understand'? [Part 2] which represents transitional teaching. Unfortunately, the students did not ask any questions.

4.6.2.2 Teachers' actions and assessment

The lesson on trigonometric equations was primarily carried out in a didactic manner because, like the other teachers observed, only *one teaching teaching-centred method predominated (STAM 5A).* The teacher was dominating in his approach of writing down answers and letting learners check their answers against his, as seen in the introductory section of the lesson. The description on trigonometric equations showed that Mr. Nare demonstrated how to key in values to do calculations [See Parts 2 & 3] and *the use of demonstrations (STAM 6AB)* in this lesson shows a minimal attempt towards a transitional approach.

In this class, teacher-student interaction was with a few individuals or with a group of learners. As already described above, the learners went to the teacher with their individual problems and he helped them to key in the values to solve the problem. However, learners had different models of calculators, which they got from friends [Part 4]. Despite the interaction with the teacher, there was *little teacher-student interaction about subject matter (chalk and talk) (STAM 7A).*

In the excerpt for Part 3, the teachers' questions were related to the method that the teacher used. His questions did not *call for recall of facts* but were directed to reproducing transmitted knowledge *(STAM 8A).* The teacher's questions did not call on the learners' ideas; rather the questions were teacher-centred.

Although no test was witnessed in this lesson, the kind of test that is given to learners relate to the kind of teaching observed. Learners are expected to solve similar kinds of problems in tests and assignments. *No quizzes are used (STAM 9A).* This observed lesson on trigonometry did not *use any form of assessment beyond grading (STAM 10A).* Students did *not raise any ideas about the subject matter (STAM 11A).*

4.6.2.3 Students' actions

Only one problem out of the ten for which the answer was written in the form (a) θ = 49,3°; (b) β = 30,5°; (c) α = 38,9°; ... given for homework was done on the chalkboard. Other writings on the board were trigonometric ratios, for example

$$\cot A = \frac{1}{\tan A} \text{ and } \sec A = \frac{1}{\cos A}.$$

No other forms of writing and other representations of ideas were used other than the ones mentioned (STAM 12A). Learners copied these writings into their notebooks. As seen in the described lesson on trigonometry, *very few questions were asked by the students (STAM 13A);* most of the questions were asked by the teacher (Part 2).

Following the description given in the opening paragraph about this lesson on trigonometry, learners were moving from one group to another inquiring about how the calculations were done. There was some *student-student interaction* that was mostly about procedures as characteristic of transitional teaching *(STAM 14B).* However, *students did not volunteer examples or analysis*, and as observed in this class, there were *no activities that were initiated by the students (STAM 15A).* All activities were teacher led. In the same way, *students were passive or ignored the teacher's procedures (STAM 16A).*

4.6.2.4 Resources and environment

The lesson on trigonometry was identified as didactic because *resources were few beyond the single text or format (STAM 17A).* In this lesson, most learners did not have hands-on experience because they lacked calculators *(STAM 18A).* Some of those who had calculators could not operate them because they were borrowed from friends. In the lesson, the teacher was the *one who controlled all the resources (STAM 19A).* Mr.Nare decided about how to deal with issues in the class; for example, he decided to send learners who did not have calculators at the beginning of the lesson away to go and look for them. In this lesson, the *locus of decision-making was teacher dominated (STAM 20A); no teaching aid displayed in this class (STAM 21A) also no examples of student work were displayed (STAM 22A).*

4.6.2.5 Summary

In this trigonometry lesson, a description of the lesson was given followed by an analysis of examples from the lesson as guided by the STAM descriptors as discussed in Chapter 3. The lesson was identified by the descriptors as primarily didactic. However, *STAM 4AB*, *STAM 6AB* and *STAM 14AB* were characterised as transitional, even though this showed very slight indication of transitional teaching. These were the part of the lesson where the teacher demonstrated how to do calculations. There were also some student–student interactions that were mostly about procedures.

4.7 Multiplication and division of terms in algebra

4.7.1 Description of the lesson (Tt7/300501/Gr11)

In this lesson, the teacher, Mr. Mosotho, was teaching multiplication of terms by working out three problems on the chalkboard as learners listened. He explained how to factorise the difference of two squares and a trinomial. The discussion went as follows:

[Part 1]

$$\frac{x^2-4}{x^2-x-6}\times\frac{6x+12}{3x-6}$$

He explained how to get factors of $x^2 - 4$

$$x^2 - 4$$

↙ ↘

$x \times x$ 2×2

The factors are (Spoken as: *Di factors ke*)

$$(x + 2)(x - 2)$$

T: To factor $6x + 12$, take out three as the common factor.

The rest of the explanation continued like this until Mr. Mosotho got to the final answer:

$$\frac{(x+2)(x-2}{(x-3)(x+2)} \times \frac{6(x+2)}{3(x+2)}$$

$$= \frac{2(x+2)}{x-3}$$

[Part2]

The explanation for a division of terms went like this as he wrote on the chalkboard:

T: How are we going to solve this? — referring to the following expression (Spoken as: *Re tlo ira bjang?*)

$\frac{3a+3b}{a^2-b^2} \div \frac{6a}{a-b}$ Take out 3 as common factor and difference of squares

$\frac{3(a+b)}{(a+b)(a-b)} \times \frac{a-b}{6a}$ Check multiplication

T: Is there anything we can do? (Spoken as: *Go na le ntho ye reka e etsang*)

$$\frac{3}{6a}$$

T: What do we get?

$$\frac{1}{2a}$$

Mr. Mosotho then went on to explain what he had done.

T: Look here, isn't it as I told you that these are fractions. When we divide I told you that the numerator becomes the denominator. We no longer have division we have multiplication, (Spoken as: *Bonang, a ke re ke le boditse gore ke di fractions. Ga re divida ke le boditse gore numerator e ba denominator. Ga re sa ba le division re ba le multiplication.*)

He continued to explain the expression that involved a trinomial

$$x^2 - x - 6$$

T: Trinomials, three terms, factors of first and last term. Each time you see a trinomial, find the factors. Isn't it you will be seeing them. (Spoken as: *Each time ge o bona trinomial o kereye difactors. A ke re o tla ba o di bona).*

[Part 3]

He wrote another problem on the chalkboard

$$\frac{2a}{4a-8}\times\frac{6a-12}{a^2}$$

T: How are we going to do this? (Spoken as: *Re tlo ira bjang?*)

T: Let's look for a common factor. (Spoken as: *Re ka nyaka common factor*)

As the bell rung, he completed the answer as follows without saying anything.

$$\frac{2a}{4(a-2)}\times\frac{6(a-2)}{a^2}$$

$$=\frac{3}{a}$$

4.7.1.1 Comments from field notes

Mr. Mosotho invited me to go with him to the staffroom and on our way I asked Mr. him why learners did not have textbooks in class with them. Mr.Mosotho said that this problem was discussed at a parents' meeting and the parents did not seem to be supportive of buying textbooks. The school hands out schoolbooks to learners to be shared. However, some leave the books at home or even loose them and steal those of others. In order to solve the learners' textbook problem, Mr. Mosotho said that he asked learners to buy a three-quire notebook at the beginning of the year to write notes at the back of their books.

4.7.2 Analysis of the lesson

4.7.2.1 Content

In this lesson, Mr. Mosotho introduced the multiplication of terms *in the form of factual content (STAM 1A)* and did not provide any *examples or interconnections to* *the real world events or previous related ideas or key ideas of the subjects (STAM 2A).* There was only one *interpretation* of the problem *(STAM 3A)* and the teaching method was presented separately as a static or algorithmic approach (STAM 4A).

4.7.2.2 Teacher's actions and assessment

This lesson was didactic because only *one teacher-centred method predominated (STAM 5A).* In this example, Mr Mosotho used the telling method to a large extent to teach multiplication of terms. He explained everything as can be seen in Parts 1 and 2. From the description of the lesson in Parts 1, 2 and 3, it can be seen that *no demonstrations, labs and hands-on activities* were used *(STAM 6A).* Moreover, in this lesson there *was little teacher-student interaction about the subject matter (STAM 7A).* Explanations were chalk and talk, as can be seen in Parts 1 and 2.

Similarly the *teacher's questions called for factual recall (STAM 8B).* The teacher showed learners how to do a division problem that was given for homework and told them the result in a factual way as he worked out the problem (see the discussion was as in Part 2).

As can be seen in the dialogue, few teacher questions were asked in this lesson. The teacher's questions were not so much directed to learners' responses to the recall of facts but towards directing their thinking to the problem that was being discussed. In this way, the teaching was of a transitional nature (*STAM 8B*).

In a like manner, in this lesson on multiplication of terms, Mr Mosotho used three examples to show learners how to multiply and divide terms. As shown in Parts 1-3, the lesson was dominated by calculating the solution to problems. The kinds of *assessment that he employed would be in the form of tests (STAM 9A);* no quizzes were used (I did not observe a lesson where a test was being written).

Furthermore, following the descriptions given of the lesson activities on multiplication of terms, in my observation there was *no use of assessment beyond grading (STAM 10A).* By the same token, as described in the lesson there *were no ideas from learners in terms of suggestions on how the lesson or problems could be* *solved (STAM 11A).* The teacher did most of the talking related to the subject factorisation and multiplication of terms.

4.7.2.3 Students' actions

The nature of the lesson is characterised as didactic because the writing that happened was in the form of *learners copying out the sums that the teacher worked out on the chalkboard; these sample writings* can be seen in Parts 1, 2 and 3 *(STAM 12A).* No student representations were used in this lesson. Similarly, there were no students' questions as can be seen in the discussion in Part 2 *(STAM 13A).* In the lesson, Mr. Mosotho presented the solution of problems on multiplication of terms by asking questions of students that related to mathematical manipulation techniques. However, he did not wait for students to answer.

In a like manner, in this lesson on multiplication of terms the teacher worked out three problems on the chalkboard explaining how to get factors of a trinomial and difference of two squares and how to simplify the problems. An example is as in Parts 1, 2 and 3. Based on these examples, *there were no student–student interactions (STAM 14A).* This was also evident in the way that the learners were seated, in desks for two learners.

Besides, *in this lesson learners did not initiate the lesson activities (STAM 15A).* The teacher was the one writing the problems on the chalkboard and working them out, whilst the learners copied these problems in their notebooks and were *passive (STAM 16A).*

4.7.2.4 Resources and environment

The lesson was didactic because resources were few beyond a single text or format (*STAM 17A*). On top of that, students looked at, but did not actively use, resources which were not related to the content (*STAM 18A*). In this lesson, no other resources apart from the teachers' textbook, chalk and chalkboard were present.

Moreover, *access to resources was controlled by the teacher (STAM 19A)* and the *locus of decision-making was teacher dominated (STAM 20A).* The teacher made all the decisions in this class. There were no teaching aids used in this class *(STAM 21A)* and there were no *examples of students' work displayed* during this lesson *(STAM 22A).*

4.7.2.5 Summary

The lesson on Multiplication and Division of terms was analysed using the 22 descriptors of STAM. It was found that in terms of all these descriptors, the lesson was didactic. As for *STAM 8AB*, the dialogue between the teacher and the students showed, that the kind of questions that the teacher asked were towards directing the students thinking towards the problem that was being solved. In this sense the lesson was identified as transitional.

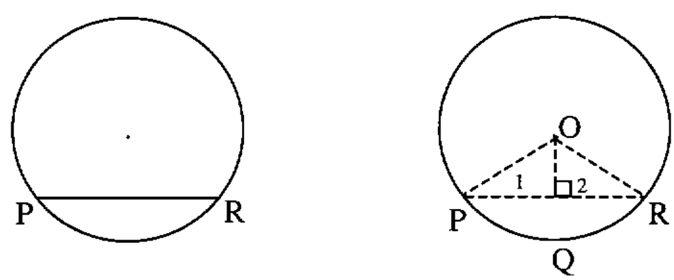
4.8. Converse of a previous theorem

4.8.1. Description of the lesson (Kt8/060601/Gr11)

In this geometry lesson, the topic was the converse of a previous theorem which was a continuation of the lesson from the previous day's lesson. On entering the class the teacher, Mr Muntu, said

T: Yesterday we did theorem one, today we are going to do the converse. He wrote the date, the topic and the heading of the theorem: *The straight line drawn from the centre of a circle at right angles to a chord bisects the chord.* He drew the following diagram, said what was given and what was required to be proved and wrote the proof of the theorem as follows:

[Part 0]



RTP: PQ = QR

Construction: Join OP and OR

Proof

Statement	Reason
In ΔOPQ & ΔORQ	
OP = OR	radii
OQ =OQ	common
Q1 = Q2 = 90°	given
ΔOPQ ≡ ΔORQ	RHS
PQ = QR	ΔOPQ ≡ ΔORQ

[Part 1]

T: In triangle OPQ and triangle ORQ, what is OP equal to?

L: (in chorus) OR

T: reason?

L: (in chorus) radius

T: OQ = OQ; what is the reason

L: (in chorus) common

T: the word perpendicular is associated with what degree?

L: (some learners answered in chorus) ninety degrees

[Part 2]

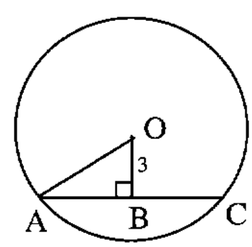
Mr. Muntu also used coloured chalk to emphasise his explanation of equal sides and equal angles. When he finished, what was required for the proof, he started all over again and repeated the explanation. Learners were watching and nodding as he spoke. However, he did not make any effort to probe learners by responding to them individually. After going through the whole proof, Mr. Muntu told them to know and memorise the theorem. Learners copied the theorem from the chalkboard into the back of their notebooks (they wrote notes at the end of the notebooks since they do not bring textbooks to class). The rest of the period was spent by learners writing class work on problems that related to the application of the theorem. The three class work problems were as follows:

1) AC = 8

Calculate

(a) AB

(b) OA

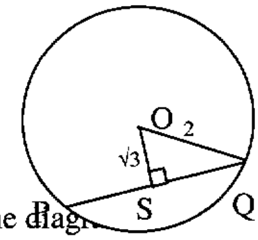


2) Calculate

(a) SQ

(b) PQ

Given the information in the dia

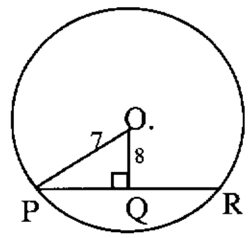


3) Calculate

(a) OR

(b) QR

(c) PR



Given the information in the diagram

[Part 3]

No mathematical instruments were used by Mr Muntu to draw these diagrams. During class work writing, I also observed that learners did not have mathematical instruments to draw lines and circles. They used Vaseline and Vicks container tops to draw circles and used pencils and pens as rulers. I observed that the student- student interactions were more on learners exchanging these objects than on mathematical ideas. Learners who did not have something with which to draw stood and waited for their turn to obtain materials. During class work, Mr Muntu was sitting in front of the class. After copying down the questions, some learners went out to show him their work. However, this work was not corrected in class.

4.8.1.1 Comments from field notes

In all my observation of teachers' lessons, this was my first impression to see a classroom like that of Mr. Muntu. There were mathematical charts all over the wall. Towards the front of the classroom, there was a hand-made chart showing a summary of quadrilaterals. Other charts were on topics such as types of angles, notes on ratio and proportion, polygons and trigonometry. The noticeboard at the back of the classroom was full of mathematics-related features. Extracts from newspaper articles on mathematics problems were pasted on the wall. I saw one big picture showing the Minister of Education, Professor Kader Asmal. I could not make out what the others were.

4.8.2 Analysis of lessons

4.8.2.1 Content

This geometry lesson was carried out in a didactic fashion because the theorem was presented *as pure facts* with no practical measurements (*STAM 1A)*- as in the lesson introduction. Also the learners were supposed to know the words of the theorem, what was given, what was required to prove, the proof itself and the conclusions drawn. No other description or explanations were given. *No examples related to real world events, or were related to ideas or key ideas of the subject* (*STAM 2A*). In a like manner, this theorem was introduced *as an absolute statement without qualifiers and there was no integration with other content. No other alternative forms were presented (STAM 3BC).* However, Mr. Muntu did check that the students followed his explanation, which could be considered as conceptual teaching [Part 1].

Furthermore, *the content of this lesson was presented as rote procedures;* "know the theorem and memorise", the teacher said *(STAM 4A)* Part 2. After having emphasised important sections, the teacher started all over again and repeated the theorem and told learners to know and memorise it.

4.8.2.2 Teacher's actions and assessment

The lesson was distinguished as being primarily didactic because, from the description provided above when Mr. Muntu taught the converse of the theorem, he told learners what the theorem was, what to prove and how to prove it. He used *two teaching approaches*, the telling method was mostly used *(STAM 5A)* and the question and answer method was also minimally used when the teacher asked learners questions and accepted their responses in chorus. In terms of STAM, this lesson is characterised by the predominance of two teaching teacher-centred methods of teaching which is in this case the telling method and the question and answer method.

In this lesson on the theorem, *the straight line drawn from the centre of a circle at right angles to a chord bisects the chord*, Mr. Muntu drew a diagram associated with the theorem, wrote what was given and what was required to prove, he demonstrated how to do the proof and subsequently drew conclusions. During the rest of the period, learners were given three problems that related to the application of the theorem. There were no hands-activities in this lesson. *According to the STAM classification this, lesson was didactic* (STAM 6A).

In this lesson, the teacher-student interactions were in the form of the question and answer method. During the proof of the theorem, the teacher continually allowed learners to give the reasons why certain quantities were equal to others [Part 1]. In their responses, the learners were answering in chorus responses, not individually; the teacher was not encouraging them to respond on an individual bases. The teacher-student interaction was chalk and talk, with *little teacher–student interaction about subject matter (Chalk and talk) (STAM 7A).* In this class, it was observed that after giving learners homework, the teacher sat in front whilst learners were writing the class work. He did not move among desks to interact with students concerning any difficulties that they might have had when doing classwork.

Furthermore, based on the example in Part 1 of the lesson, the kind of questions used called for *factual recall (STAM 8A).* In this lesson, there were *no quizzes (STAM 9A)* and moreover, use of *assessment beyond grading* was not present *(STAM 10A).* Checking of learner's knowledge was only in the form of giving them class work problems related to the application of the theorem. In this geometry lesson, the teacher did not seek students' *ideas about subject matter (STAM 11A).*

4.8.2.3 Students' actions

What is more, students' *writings and other representations of ideas were not used (STAM 12A).* Writing and representation used in this class was in the form of learners copying the theorem into their notebooks and writing class work that related to the theorem [Part 0 exercise and the latter portion of Part 2]. No other representations of ideas were used. Answers to verbal questions were few and very short, simple words. This lesson was didactic because a closer look at the lesson proceedings in Parts 0 and 1, in this lesson indicate that *there were no student questions (STAM 13A).* The learners listened as the teacher was explaining the theorem.

Also, student–student interaction in this lesson was nonexistent in terms of subject matter *(STAM 14)*. However, the interaction that I observed was when learners were exchanging pencils etc. [Part 3] but these interactions seemed not to be about mathematical procedures. As observed in this lesson there was no student-initiated activity. The teacher initiated all the activities. Students did *not volunteer any examples or analysis (STAM 15A)*. As observed they did not even have textbooks with them.

In the same manner, *students were passive (STAM 16A)*. In my opinion, students accepted procedures and roles as assigned by the teacher without questioning them.

4.8.2.4 Resources and environment

Again, *no other resources were present (STAM 17A)*. Neither the teacher nor the student had mathematical instruments with which to draw. All drawings were done by free hand. Also, there were no other resources used for the students except for the chalkboard *(STAM 18A)*.

Similarly, in this lesson *access to resources was controlled by the teacher (STAM 19A)* and the *locus of decision-making was teacher dominated (STAM 20A)* and, decisions were in the hands of the teacher. Furthermore, few *teaching aids were displayed (STAM 21A)*. During this lesson, the display of teachings aids is captured in this field note record about the mathematical charts all over the wall illustrating many aspects of mathematics including extracts from newspapers illustrating mathematics in everyday life even though these were not integrated in the lesson. However, *no student work was displayed in* this geometry lesson *(STAM 22A)*.

4.8.2.5 Summary

This lesson on the converse of a previous theorem was analysed using STAM. A description of the lesson was given followed by the analysis of the lesson in each of the 22 STAM descriptors as discussed in Chapter 3. It was found that in terms of all the STAM descriptors the lesson was identified as didactic. However on one descriptor, *STAM3BC*, the lesson was characterised as moving towards conceptual teaching, when Mr. Muntu did check that the students followed the explanation that he gave.

4.9 Gradient of parallel and perpendicular lines

4.9.1 Description of the lesson (Kt9/070601/Gr 12)

[Part 1]

On entering the class the teacher, Mr Naka, wrote on the chalkboard, *Gradient of parallel lines.*

$y = m_{-1}x + c$ and line $y = m_{-2}x + c$ (I do not know why he wrote minus signs).

T: If lines are parallel(//) they will have the same gradient. $m_1 = m_2$

The learners were writing all this down in their notebooks. Next he wrote,

Gradient of perpendicular lines.

If the line $y = m_1 x + c$ and line $y = m_2 x + c$ are perpendicular the product of the gradient is minus one.

This simply means $m_1 \times m_2 = -1$. If I know the gradient of a line then I can get the gradient of another line. (He initially wrote $y = m_{-1}x + c$, then after a question by a learner he erased the negative signs).

T: Don't forget that this information is important.

T: This is another important example, he said, as he wrote on the chalkboard:

Find the equation of a line:

If you are given 2 points use this one

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_2)$$

If given gradient (m) and one point on the line use this one

$y = mx + c$

[Part 2]

T: You can find an equation of a line given the gradient and one point.

A figure drawn on the board was used for the following exercises:

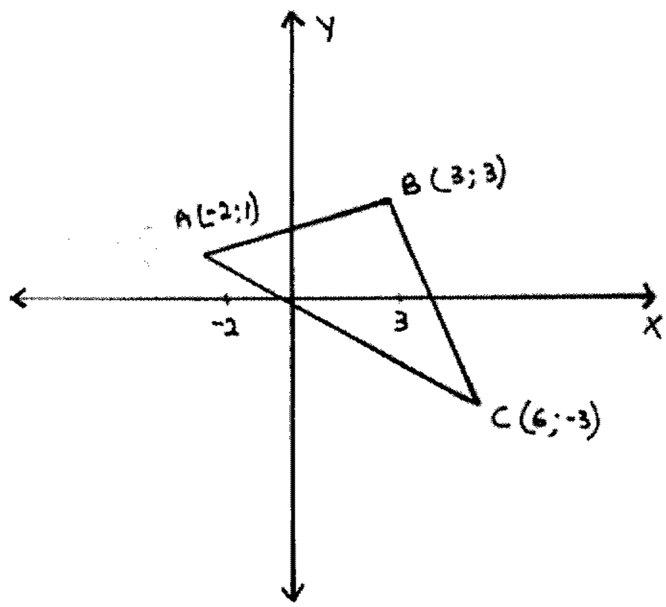


Figure 4.1: A sketch to determine the equation of line AB and AC

T: Let us determine the equation of the line AB

A (-2; 1) and B (3; 3).

The learners were copying

$$y-1=\frac{(3-1)}{3-(-2)}[(x-(-2)]$$

$$y-1=\frac{2}{3+2}(x+2)$$

$$y-1=\frac{2}{5}(x+2)$$

$$y-1=\frac{2}{5}x+\frac{4}{5}$$

$$y=\frac{2}{5}x+\frac{4}{5}+1$$

$$y=\frac{2}{5}x+1\frac{4}{5}$$

$$=\frac{2}{5}x+\frac{9}{5}$$

$$= m\frac{(2)}{5}$$

One learner asked: How did you get nine? (Spoken as: Nine *o e kereile bjang.*)

Mr. Nare explained as follows from the equation $y = \frac{2x}{5} + \frac{4}{5} + 1$

$$\frac{4}{5} + 1 = \frac{4}{5} + \frac{5}{5} = \frac{9}{5}$$

T: Now equation of AC (from the same diagram) using A (-2; 1) and C (6; -3)

Mr. Nare worked out the problem on the chalkboard. Only a few learners responded in chorus as he explained. Some learners were copying and Mr Nare wrote as he talked.

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_2)$$

$$= \frac{-3-1}{6-(-2)}[(x-(-2)]$$

$$= \frac{-4}{8}(x+2)$$

$$= \frac{-1}{2}(x+2)$$

$y = \frac{-1}{2} - 1$ (He did not explain how he made these changes)

$$y = \frac{-1}{2}x - 1 + 1$$

$$y = \frac{-1}{2}x$$

T: Next the equation of BC

Firstly, he wrote the equation, on the chalkboard and continued as follows:

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_2)$$

$$y - 3 = \frac{-3-3}{6-3}(x-3)$$

$$y = \frac{-6}{3}(x-3)$$

$$y = -2(x-3)$$

$$y = -2x+6$$

$$y = -2x+6+3$$

$$y = -2x+9$$

After completing to write these details on the board Mr Nare explained.

T: The line goes down, the gradient is negative, and when the line goes up, the gradient is positive. (Spoken as: *laene e a theoga gradient negative ya nyologa gradient e positive).*

[Part 3]

The following exercises then were written on the chalkboard and Mr. Naka drew the following diagram.

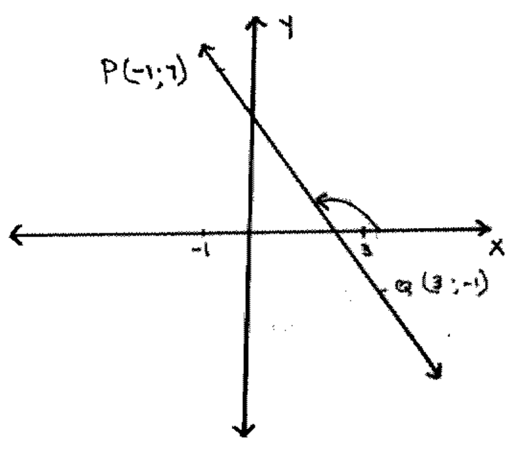


Figure 4.2: A sketch of line PQ

P (-1; 7) and Q (3; -1) are 2 points on the Cartesian plane. Determine

(a) Length of PQ (leave answer in surd form)

(b) The coordinates of m, the mid-points

(c) The equation of PQ in the form y = …

(d) The size of θ, the angle between PQ and positive X-axis

(e) The equation. Of a line, which is parallel to PQ, passes through the pt. (-5; 1). The equation must be in the form y = …

T: I want you to look at (e) the first one is not a problem, it's homework you may start writing it now. (Spoken as*: I want you to look at (e) the first one ha e tshwenye. Its homework. O ka nna wa e thoma nou.)*

L: Teacher, don't you want to start it with us (Spoken as: *Teacher, a o nyake go e thoma le rena.*)

T: Number (d) is the angle of inclination

T: No. (e), I can only guide you. When the lines are parallel the gradients are the same. (Spoken as: *Ha di le parallel di gradient, di a tshwana*)

[Part 4]

4.9.1.1.Comments from field notes

I saw only one textbook on a desk but the learners never opened it. Learners were seated in groups but, as I observed, their discussions seemed ineffective. Learners were busy copying and writing the problems written on the board. The teacher was moving around but it was difficult to read on the board because it was full of chalk. Four learners were sleeping on their notebooks. Some were writing and looking through pages at the back of their exercise books (apparently looking for formulas). Some learners were asking questions from the teacher, other learners were writing letters which looked like English homework. One learner took a colleague's book and copied. Others were doing problems that were written on the board and they kept paging back in their books. Learners used calculators for every single calculation and shared rubbers and calculators with each other. One learner asked another, apparently an able learner, what she got for the answer. After telling her she tippexed out her answer. Three girls were writing something different but the teacher did not have the time to go near them.

4.9.2 Analysis of the lesson

4.9.2.1 Content

The lesson on the gradient of parallel and perpendicular lines was largely conducted in a didactic way because the content was *presented in the form of descriptions (STAM 1A)* as shown in Part 1 with the introduction of parallel and perpendicular lines; diagrams also were used, for example the Part 3 exercises that required facts to solve them. There were no descriptions or explanations in the exercise. In a like manner, Parts 1-3 showed that the lesson proceedings on gradients of parallel and perpendicular lines had *no examples or interconnections to real world events, related ideas or key ideas of the subject (STAM 2A).*

Mr Naka used diagrams to show the directions of the lines whose gradient was determined. Part 2 shows that after determining the line AB, for example, the teacher drew the attention of learners to the gradient – " the line goes down, ... In this case, some alternate interpretations to the content were given, characteristic of transitional teaching *(STAM 3AB)*. Mr Naka gave descriptions of the conditions for parallel and perpendicular lines and gave exercises that related to the applications of these conditions to problems. There was no explicit mention of 'how we know'; the mathematical method of determining the equation of the line AB was in the form of mathematical computation *(STAM 4A)*.

4.9.2.2 Teachers' actions and assessment

The lesson is classified as didactic because *one or two teacher-centred methods predominated (STAM 5A)*. In this case, the teacher's method as shown in the description above is the telling method and the problem-based method. The teacher was telling learners the formula, showing them how to use it in solving problems on equations of lines AB, AC and BC [See Part 1 and 2]. Similarly, the lesson proceedings in Parts 1-4 show that, Mr Nare wrote the formulas, worked out problems and gave homework, *no hands-on activities or demonstration were used in this lesson (STAM 6A).*

The lesson was didactic because there was *little teacher-student interaction about the subject matter (chalk and talk) (STAM 7A)*. In this lesson on applications of the formula of gradients of lines, it was observed that the kind of teacher-student interactions were in the form of students' reactions to questions related to solutions of problems, mostly through chorus responses [Part 2]. This lesson is characterised by little interaction about subject matter (chalk and talk). There were no teacher student interactions about the correctness of students' ideas. In a like manner, the *teacher's questions called for factual recall (STAM 8A)*. The teacher asked very few questions. The lesson description on gradients of parallel and perpendicular lines shows the teacher explaining how to find gradients of lines. The kinds of questions that the teacher asked in his lesson can be seen in the form of homework problems given in Part 3 that questions were calling for application of learned formulas. In this lesson, the kind of assessment used was group work assessment and *there were no quizzes used (STAM 9A)*. Also, the teacher did *not check the knowledge of learners in this lesson (STAM 10A)*. He worked out problems on the chalkboard which learners copied. The nature of the lesson was didactic because the teacher *did not seek students' ideas about the subject matter (STAM 11A)* and the students had no suggestions about the subject matter.

4.9.2.3 Students' actions

The sample writings in this lesson as shown in Parts 1-3 were in the form of copying notes and formulas and problems that had been worked out and written on the chalkboard. *No other forms of writing and representations of ideas were used (STAM 12 AB)*. Most of these writings were reconfigurations of information provided as in this aspect of writing notes, formulas and problems, the lesson was transitional in terms of STAM characteristics. However, in the same way, there were *few students' questions (STAM 13A)*. For example in Part 1, a student asked Mr. Naka why the equation was written as $y = m_{-1} + c$. He responded by wiping out the minus sign (perhaps he realised that it was confusing students).

During this lesson, the teacher gave learners formulas and sample examples were worked out the chalkboard. It was observed that the learners did not bring their textbooks to class and the teacher wrote notes and worked out problems on the chalkboard [Part 1-3]. It was also observed that few students *were interacting among themselves (STAM 14A)*, or with the teacher, to check each other's answers [Part 4].
The lesson is characterised as primarily didactic because in this lesson on gradients of parallel and perpendicular lines, students *did not initiate or volunteer examples or analysis (STAM 15A)*. The teacher provided all the examples. Similarly, *students were passive or ignored the teacher's procedures* (*STAM 16A*). From the description of the lesson students accepted procedures given by the teacher.

4.9.2.4 Resources and environment

There were no extra *resources in the lesson except the textbook and chalkboard (STAM 17A).* Also, *students were not asked to use any resources (STAM 18A).* Besides, *access to the chalkboard was controlled by the teacher (STAM 19A)* and decisions were in *the hands of the teacher (STAM 20A).* The lesson was distinguished as didactic because *few teaching aids were displayed (STAM 21A)* and *no examples* of students work were displayed in the classroom *(STAM 22A).*

4.9.2.5 Summary

This lesson on gradients of parallel and perpendicular lines was analysed using the 22 STAM descriptors as discussed in Chapter 3. In terms of these descriptors the lesson was characterised as primarily didactic. However, in terms of line 3 B and line 12 B the lesson displayed some characteristics of transitional teaching.

4.10 Linear graph

4.10.1 Description of lesson (Dt10/130901/Gr10)

This lesson involved four equations of linear graphs that had been given for homework. Mr. Nare worked out the first equation $y=-x+4$. Learners were asked to draw a table with x- values as follows and they had to work out the y- values and draw a table as illustrated in the first part of the lesson.

[Part 1]

x	- 3	- 2	-1	0	1
y	7	6	5	4	3

Figure 4.3: A table of x and y values for the graph of $y=-x+4$

The teacher made the following substitution on the board

$$y=-x+4$$
$$=-(-3)+4$$
$$=3+4$$
$$=7$$

The table was completed with the help of learners. When all the values were calculated the teacher plotted the graph without using a ruler.

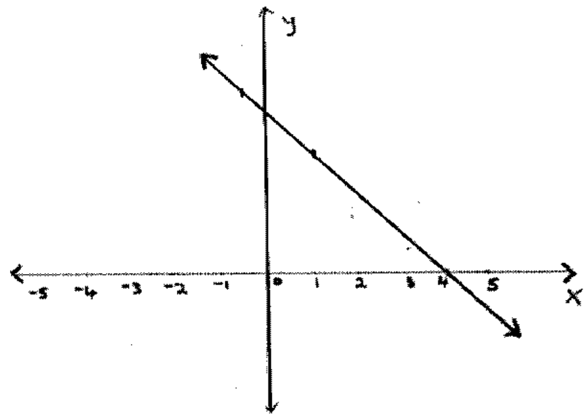


Figure 4.4: A sketch of the graph of $y = -x + 4$

Mr. Nare then offered the following advice to the learners.

T: You are in trouble if you replace x values wrongly. (Spoken as: *O mo kotsing ge o repleisa divalues tsa x wrong*)

The line was very crooked and he kept saying that he did not use a scale. He then told them to do the rest of the equations on their own following the example that he had demonstrated. The graphs were (a) $y = -2x + -1$; (b) $y = x + 4$; (c) $y = 2x + 1$.

[Part 2]

Next, Mr. Nare showed the students how to determine the x and y intercepts using the example presented below. Learners watched the teacher as he explained using the equation $y = 2x + 1$ to find the x intercept. He wrote on the chalkboard

To find the x – intercept substitute $y = 0$

and worked the problem out as follows:

$$y = 2x + 1$$

$$0 = 2x + 1$$

$$-2x = 1$$

$$x = \frac{-1}{2}$$

$$x = -0{,}5$$

$$x(-0{,}5;0)$$

Comment: *I thought this was a funny way to write.*

L: Sir were does the 5 in – 0,5 come from? (Spoken as: *Meneer 5 in –0,5 e hlaha kae?*).

T: The teacher explained that it came from $\frac{-1}{2}$ through division.

In addition the teacher drew the Cartesian plane, indicating the x- axis and the y- axis and the different quadrants. I noticed that learners had difficulty plotting the graph. Mr. Nare used a learners' ruler to show the location of $+0{,}5$ and $-0{,}5$ on the x- axis. There was no hands-on activity in this class.

Next he wrote y intercept: $x = 0$

$$y = 2x + 1$$
$$= 2(0) + 1$$
$$= 0 + 1$$
$$= 1$$
$$y(0;1)$$

[Part 3]

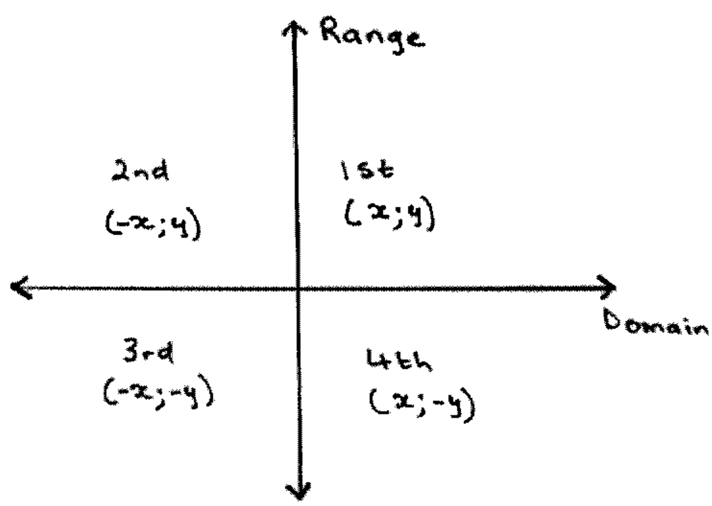


Figure 4.5: A sketch of the Cartesian plane

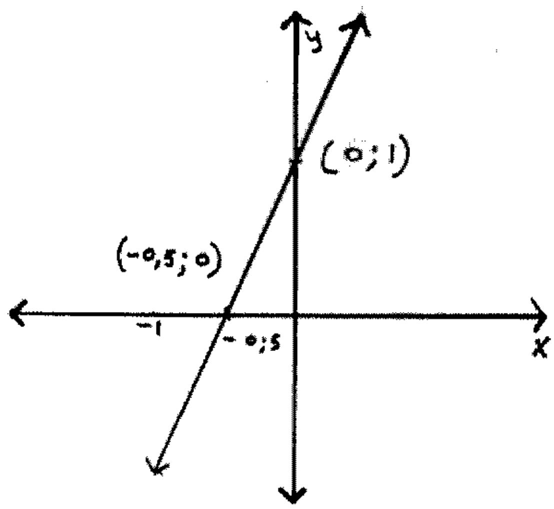


Figure 4.6: A sketch of the graph of $y = 2x + 1$

Mr. Nare plotted the graph and told the learners to follow his examples and do the same with the other equations and enquired if there were any problems in understanding the task.

T: Is there any one with a question?

Mr Nare told the learners to do class work on finding the x and y intercept of the graphs that were given for homework in Part 1, and then he drew the graph.

4.10.1.1.Comments from field notes

I noticed that there were three boys who had finished using the table-substitution method to calculate the values of *y* and drawing graphs. The teacher called these three boys to the board and showed them how to use the x-and y-intercept. As he explained to them he said "They will catch up with you along the way"(Spoken as" *Ba tla le tshwara ko tseleng*). Later he showed this method to the rest of the learners.

4.10.2 Analysis of the examples of the lesson

4.10.2.1 Content

This lesson on linear graphs was classified as didactic because the *structure of the content was factual content* about plotting the graph (*STAM 1A*). In the same way, with reference to what transpired in this lesson on linear graphs as can be seen in Parts 1-3, the examples given had *no interconnections to real world events, related* *ideas or key ideas of the subject* (*STAM 2A*). These examples only had connections to strategies of drawing linear graphs.

It has been mentioned that when showing learners how to plot the linear graph, the teacher's line was very crooked and was not corrected by him. Seeing that learners had difficulties also in substituting x for y values in drawing the table and also plotting the graph this way of presenting the concept of a linear graph offers a *limited* picture of this concept *(STAM 3A).* In presenting the technique of drawing a linear graph, Mr Nare firstly showed learners how to plot the graph using a table but he made *no explicit mention of the purpose* of the task *(STAM 4A)* [Part 1], given the *x* values and also using the intercept method. Learners had difficulties with calculations and plotting graphs. In this lesson, it has been shown that the teacher used a form of representation that was not compatible with acceptable forms of representing the x- and y- intercepts [See Part 2].

4.10.2.2 Teacher's actions and assessment

This lesson on linear graphs was classified as didactic because as seen in the example above the teacher used *the telling method to* show learners how to calculate the values and draw the graphs [See Parts 1-3] *(STAM 5A).* In the same way, following the description of the activities in this lesson of drawing linear graphs, Mr. Nare showed the learners how to calculate the *x* and *y* values to determine the *x*- and *y*- intercepts and graphs [See Parts 1-3]. The only demonstration in this lesson was when Mr. Nare used a learners' ruler to show the location of + 0,5 and – 0,5 on the *x*- axis. *There was no hands-on activity in this class (STAM 6A).*

Likewise, in this class there was *little teacher-student interaction (STAM 7A).* The teacher showed learners how to calculate the x and y values and to plot the graphs as seen in Parts 1- 3 but did *not seek contributions from learners (STAM 11A).* Similarly, there were few teacher questions in this lesson as seen from the lesson description in Parts 1-3 *(STAM 8A).* The teacher was showing learners how to calculate values and plot a linear graph in this lesson and those that followed *(STAM 9A). No quizzes were used for testing, only tests* at the end of the term and there was *no use of assessment beyond grading (STAM 10A).*

4.10.2.3 Students' actions

The form *of writing in* this lesson concerned producing the tables for determining the x and y values and drawing graphs [Parts 1-3] (*STAM 12A*). This lesson was characterised as didactic because, there *were few student questions* (*STAM 13A*). In this lesson only one learner asked a question [Part 2]. Similarly, this lesson description shows no evidence of *student- student interactions* (*STAM 14A*). Also, during this lesson there were *no examples that were volunteered by the students (STAM 15A);* all the examples were given by the teacher. In a like manner, the learners *accepted the teacher's procedures and they did not question them (STAM 16A).*

4.10.2.4 Resources and environment

The available resources for this lesson were the chalkboard and chalk *(STAM 17A).* There were no resources beyond the teacher's textbook, chalk and board. Moreover, learners did not have textbooks with them (*STAM 18A).* Similarly, the nature of the lesson was didactic because, *access to resources was controlled by the teacher (STAM 19A)* and the *locus of decision-making is teacher dominated (STAM 20A).* Also, no *teaching aids were displayed nor integrated with content (STAM 21A).* Lastly, no *examples of students' work was displayed (STAM 22A).*

4.10.2.5 Summary

In this lesson on Linear equations, a description of the lesson is given followed by the analysis of the lesson guided by 22 STAM descriptors. It was found that in all the 22 descriptors this lesson was identified as didactic. There were no characteristics that related to transitional or conceptual teaching.

4.11 Midpoints of lines

4.11.1 Description of the lesson (Kt11/120601/Gr12)

The teacher, Mr. Naka, entered the class and started writing solutions to homework on the chalkboard without saying a word. (It was difficult to copy what was written on the chalkboard which was full of white chalk and needed a wash with water. After working out the problems, the teacher did not verify whether the learners got problems right or whether or not the learners understood the problems. The following sketch was written on the chalkboard.

[Part 1]

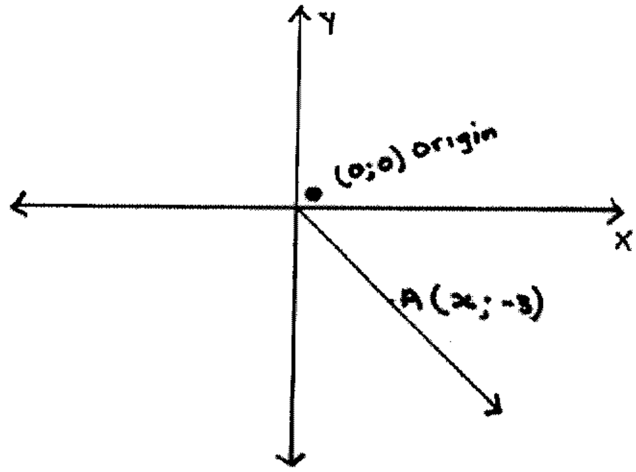


Figure: 4.7: A sketch to determine the midpoint of lines from homework problems

Some learners were writing, others were watching, paging through their books, probably checking on formulas.

$$OA = 5 \text{ Given}$$

$$AO = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$$= \sqrt{(x-0)^2} + (-3-0)^2$$

$$= \sqrt{x^2} + 9$$

$$5 = \sqrt{x^2} + 9$$

$$25 = x^2 + 9$$

$$25 - 9 = x^2$$

$$x^2 = 16$$

$$x = \pm 4$$

T: Any questions?

L: No questions (said the learners).

T: We don't know *x*, we know *y*. He explained the mid-point using the diagram below. The learners copied as he wrote. Some were watching. However, Mr. Naka never asked the learners questions or involved them in any way.

[Part 2]

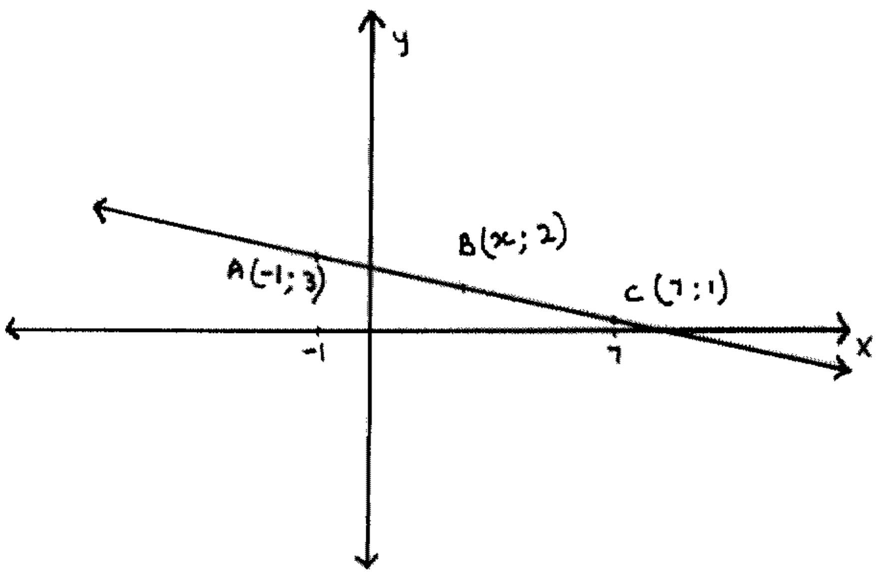


Figure 4.8: A sketch to determine the x coordinate of the midpoint of line ABC

T: AB=BC mid-point given, then he wrote:

$$\sqrt{(x-1)^2+(2-3)^2}=\sqrt{(x-7)^2+(2-1)^2}$$

$$\sqrt{x^2-2x+1+1}=\sqrt{x^2-14x+49+1}$$

$$x^2-2x+2=x^2-14x+50$$

$$2x+14x=50-2$$

$$16x=48$$

$$x=3$$

$$x=3$$

Mr Naka talked as he wrote and the learners were quiet; they were busy copying from the board. However, some learners were looking outside, others were paging through books. As he talked, Mr Naka kept on speaking.

T: Are we agreed? What are we solving for? Does it give sense? (Spoken as: *A ra utlwana, A na re batlang?*)

L: Yes.

Still, he drew a line ABC with midpoint B diagram, as shown below, and illustrated how to determine the midpoint of the line given A (-1; -1); C (-3; 8), for example. He wrote the formula, as shown below, and told learners to remember that and worked out examples.

[Part 3]

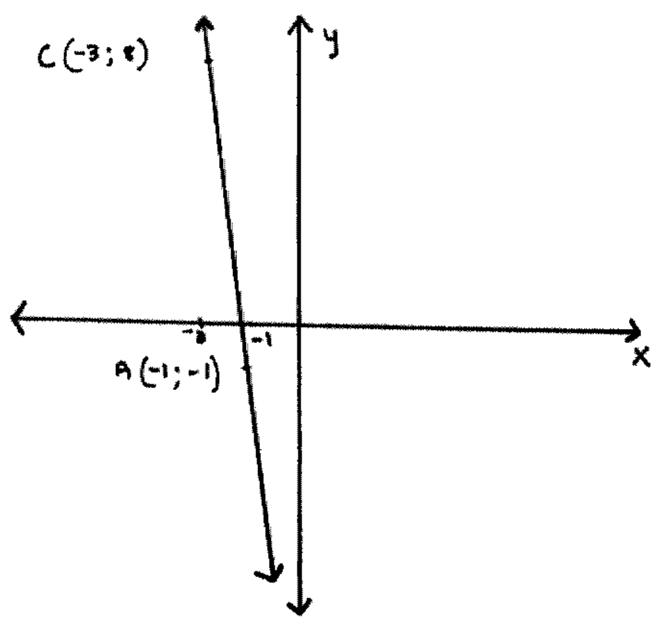


Figure 4.9: A sketch to determine the midpoint of line AC

Mr. Naka wrote MP $_{AC}$

$$\frac{(x_2 + x_1)}{2};\frac{(y_2 + y_1)}{2}$$

$$= \frac{-1 + (-3)}{2};\frac{-1 + 8}{2}$$

$$= \frac{-1 - 3}{2};\frac{7}{2}$$

$$= (\frac{-4}{2}; \frac{7}{2})$$

$$= (-2; \frac{7}{2})$$

Mid-point then he writes in brackets (N.B) [I think he meant that they should take note of the homework reference]

He gave homework from Page 109 Exercise 4.3 and read out once only--Number 1, (a), and 1(c), 2 (a), 7 (b), 7(c), and 3.

4.11.2 Analysis of the lesson

4.11.2.1 Content

The lesson on midpoints of lines is classified as didactic because the structure of the content is *in the form of facts* (*STAM 1A*). In this lesson, the teacher was doing problems related to calculating the midpoints of lines as shown in parts 1-3 of the lesson description. Looking at the examples given, there were *no examples that showed interconnections to real world events, related ideas or key ideas of the subject* (*STAM 2A*). Similarly, there was only one *interpretation of how to do the calculations (STAM 3A)* and the procedure was given in an *algorithmic approach (STAM 4A).*

4.11.2.2 Teacher's actions and assessment

This lesson is identified as didactic because based on the discussion on this lesson on midpoints; the method that the teacher used *was the telling method.* He was the one talking showing learners how to solve problems *(STAM 5A).* Similarly, the lesson proceedings as appearing in Parts1-3 indicate that *no demonstrations, labs, hands-on activities were used in this lesson* (*STAM 6A*). In a like manner, there was *little teacher-student interaction about subject matter (chalk and talk)* (*STAM 7A*), the teacher was the one talking in this lesson as shown in the problem solutions in Parts1-3.

Moreover, the teacher's *questions called for recall (STAM 8A)*. Few questions in this lesson were asked by the teacher but these were of the form, "any question? Are we agreed?", without waiting for a response. No questions were asked that called for recall of facts. In a like manner, in this lesson, *no quizzes were used in assessment only tests (STAM 9A)*. Again, *uses of assessment beyond grading were absent (STAM 10A)*. Moreover, the lesson was didactic because the teacher *did not seek out students' ideas about subject matter (STAM 11A)*.

4.11.2.3 Students' actions

In the same way, writing and other representations of ideas were not used and rather short answers predominated (*STAM 12A*). There were *few student questions (STAM 13A)* and *student-student interaction was rare (STAM 14A)* also *students' rarely volunteered examples or analysis (STAM 15A)*. The lesson was didactic in nature because students were passive *or ignored teachers' procedures (STAM 16A)*.

4.11.2.4 Resources and environment

Resources were little *beyond the single text or format* (*STAM 17A*). Similarly, in terms of resources, students *looked at, but did not actively use, resources* (*STAM 18A*). However, in this presentation there were no resources other than the chalkboard, the chalk and the teachers' textbooks. Furthermore, *access to resources were controlled by the teacher (STAM 19A*) and the *locus of decision-making was teacher dominated (STAM 20A)*. Also, *no teaching aids were displayed and (STAM 21A)* no *examples of students' work were displayed (STAM 22A)*.

4.11.2.5 Summary

In this section, a description of the lesson on the midpoints of a line was given followed by analysis of the lesson using each of the 22 descriptors of STAM as detailed in Chapter 3. The analysis of the lesson proceedings revealed that in all the STAM descriptors the lesson was didactic. There were no descriptors which identified the lesson to be transitional or didactic.

4.12 Perpendicular bisector

4.12.1 Description of the lesson (Kt12v/190502/Gr12)

The teacher, Mr. Muntu, began the lesson by drawing a sketch to show the line segments AB with points A (-2, 2) and B (7; 6) and the midpoints represented by the point M (x; y) as in the following diagram.

[Part1]

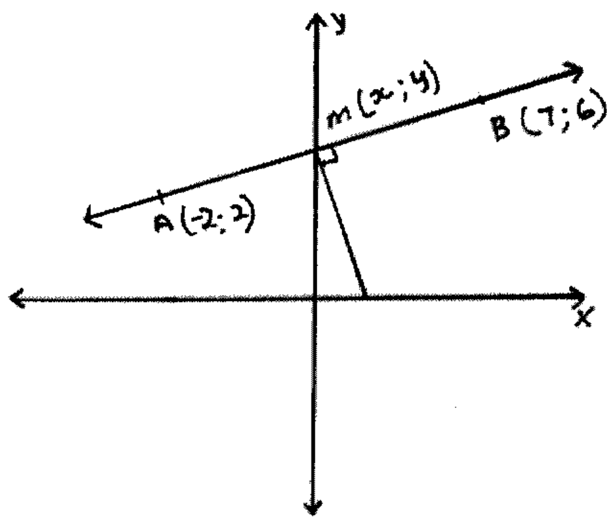


Figure 4.10: A sketch to determine the perpendicular bisector of line AB

The perpendicular bisector of the line segment AB was to be determined. Whilst pointing at the diagram he said:

T: We are told to find what?

L: The perpendicular bisector (in chorus).

The teacher uttered the following statements:

T: If two-lines are perpendicular to each other, what is the effect of the gradient?

T: If two lines are parallel to each other what is the effect of the gradient?

T: Remember I said that if the first line is perpendicular to the second line, therefore,

$$L_1 \perp L_2$$

$$mL_1 \times mL_2 = -1$$

T: You still remember that? Right?

He continued to say,

T: Now, here the term perpendicular means the line is perpendicular to what? (Pointing at the diagram)

Line segment AB (Both the teacher and the learners said)

He further explained that the line that is perpendicular to the mid-point is the perpendicular bisector, which means this side is equal to that side — pointing at the diagram $AM = AM$.

T: Obviously if the line is perpendicular it will form an angle and that angle is called what? It is equal to 90 degrees (Learners also join in to say it is equal to 90 degrees).

Throughout the lesson, the teacher was asking a question and answering it at the same time with learners.

[Part2]

The teacher gave what he called the four conditions associated with gradients orally. (These formulas were not written on the chalkboard. I have written them here to clarify the facts. I also felt that he should write down these formulas or even ask learners to give them to him.)

First condition, if given the gradient m and y- intercept c, then they should use the formula $y = mx + c$.

Second condition, if they are given any point and the gradient they should use the point gradient form $y - y_1 = m(x - x_1)$.

Third condition, if given any two points and told to find the equation then the formula to use is called the double gradient formula:

$$y - y_1 = \frac{y_2 - y_1(x - x_1)}{x_2 - x_1}$$

T: Do you still recall?

Fourthly, if given the intercepts on x and y axis, the formula to use is

$$\frac{x}{a} + \frac{y}{b} = y$$

After having stated these conditions orally, Mr. Muntu said

T: Do you follow?

L: Yes (in chorus)

H e continued to say that they needed to find the gradient of line AB first

T: By the way, what is the formula for gradient?

L: Change in y on change in x. (in chorus)

T: Come again?

T: Yes, change in y on changing x, which is $\frac{y_2}{x_2}$ - $\frac{y_1}{x_1}$.

$$M_{AB} = \frac{1}{2}$$

T: Now that the gradient of AB is found, we can find the gradient of this perpendicular bisector. Do you understand that?

The teacher explains how to find the gradient of the perpendicular bisector using the definition, mL_1 x m L_2 = - 1. He further explained that L_2 will be found by multiplying with the multiplicative inverse of half.

$$\frac{1}{2} \times -2$$

T: If we multiply –1 by half what is the answer? The answer is –2. Can you see?

T: Yes it is true. The product of the gradients is always equal to –1.

T: Do you follow?

L: Yes

[Part 3]

From here the teacher repeated the four conditions that were mentioned earlier on. He determine the midpoint of line segment AB as follows (3; 4)

The equation of the perpendicular bisector was determined as:

$$y - y_1 = m(x - x_1)$$

$$y - 4 = -2(x - 3)$$

$$= 2x + 6$$

$$\text{or } y = -12x + 10$$

T: This is the equation of the perpendicular bisector, understand?

L: Yes

[Part 4]

T: To recap, to find the equation of a perpendicular bisector of a line segment AB if given two points...(he goes through the four conditions again).

Now again, Mr. Muntu repeated the whole lesson from the beginning also using the diagram as he talked. He continued to pose questions and answering them together with the learners. For example, if two lines are perpendicular, the product will be equal to, ...(he left them to complete the word) and then they all answered minus one.

He gave the following class work:

The straight line $y = -\frac{1}{2}x + \frac{5}{2}$ cut the $x^2 + y^2 = 25$ in P and Q

(a) Find the coordinates of P and Q

(b) Prove that the perpendicular bisector of PQ passes through the centre of the circle.

4.12.2 Analysis of the lesson

4.12.2.1 Content

The lesson on midpoints of lines was classified as didactic because the content in this lesson as described was in the *form of factual knowledge (STAM 1A)*. This is seen in the manner in which the teacher kept repeating information [Part 3] of the lesson.

In the same way, in this lesson the teacher was teaching about the perpendicular bisector of a line. From the description of the lesson there were *no examples or interconnections of the content to real world events, related ideas or key ideas of the subject (STAM 2A)*. The examples that the teacher gave in the lesson were about determining the perpendicular bisector of the line that was drawn on the chalkboard see Parts 1 – 3.

Similarly, the description of the lesson shows that the teacher [in Part 2] gave what he called the four conditions of determining the equation of a line. No practical reference was made to what the perpendicular bisector of a line means in the practical sense. The teacher gave a *narrow view of teaching the content that was restricted to use of formulas in finding* the gradients, equations of lines and coordinates of the midpoint *(STAM 3A)*.

In this lesson description, when presenting how to determine the perpendicular bisector of the line, Mr Muntu kept repeating the four conditions that he regarded as important for learners to know in this section [Part 3]. After determining the equation of a perpendicular bisector, he said 'to recap' [Part 4]. Throughout the lesson, Mr Muntu kept on saying, 'Do you follow? Do you understand?' In my view this implies that the teacher was emphasising learning of these concepts following rote procedures and the repetition was to ensure that this knowledge was committed to memory. So the *mathematical method was presented separately as static or algorithmic approach (STAM 4A).*

4.12.2.2 Teacher's actions and assessment

This lesson was identified as didactic because Mr Muntu, when teaching how to find the perpendicular bisector of a line, referred to a diagram to show the positions of the line and the midpoint. However, in his explanation of the equation of the perpendicular bisector of a line, he *used the telling method (STAM 5A).* Throughout the lesson, he continually kept repeating information and also said statements where he continually answered himself as for example "if the line is perpendicular, it will form an angle and that angle is called what? It is equal to 90 degrees" (Learners also joined in to say "It is equal to 90 degrees").

Similarly, the lesson proceedings, as appearing in Parts 1-3, indicate that *no demonstrations, labs, hands-on activities were used in this lesson (STAM 6A).* In a like manner, *there was little teacher-student interaction about the subject matter, rather the lesson was chalk and talk (STAM 7A)* with Mr. Muntu the one talking. Teacher-student interaction was in the form of learners responding to the teachers' questions in the form of chorus responses that also involved them repeating answers with the teacher [Parts 1-3].

Moreover, *the teacher's questions called for recall (STAM 8A).* Most of the questions that the teacher asked in this lesson were calling for knowledge in the form of facts stated by the teacher as demonstrated by questions such as "You still remember that? Now, here the term perpendicular means the line is perpendicular to what? The teacher together with the learners responded 'line segment AB' [Part 1].

In a like manner, *assessment was by tests and quizzes only (STAM 9A)*. In this lesson, no quizzes were used in assessment, only tests. Similarly, the lesson was didactic because *uses of assessment beyond grading was absent (STAM 10A).* Moreover, the lesson was didactic because the teacher did not solicit *students' ideas about the subject matter (STAM 11A).*

4.12.2.3 Students' actions

In the same way, *writing and other representations of ideas were not used. Short answers predominated* (*STAM 12A*). In this lesson on the perpendicular bisector of a line segment, the writings were the working out of the gradients of lines, the equations of lines and the coordinates of the midpoint as well as the exercise that was given at the end of the lesson. Learners copied these writings into their notebooks.

In the same way, a closer look at the description of this lesson shows that there was *no question that was asked by learners (STAM 13A) a*ll the questions were asked by the teacher [Parts1 - 4]. The description of the lesson on the perpendicular bisector of a line showed that there was *no student-student interaction (STAM 14A).* In this lesson, the learners were sitting in groups but there was no evidence of group discussion taking place. Learners were seen passing pens and books to each other. Likewise, following the description of the lesson, *the students did not volunteer examples (STAM 15A).* As seen in the lesson description the examples were given by the teacher. Again, the lesson is didactic in nature because, *students were passive (STAM 16A).*

•

4.12.2.4 Resources and environment

On the same breadth, *resources were little beyond a single text* (*STAM 17A*). The only resources available in this lesson were the chalkboard, the chalk and the teacher's textbooks. Similarly, in terms of resources, *students looked at, but did not actively use resources.* There were *no resources that learners used in this lesson that were related to the content* (*STAM 18A*). Furthermore, *access to resources was controlled by the teacher (STAM 19A)*. The learners did not have any suggestions about the subject matter. Also, the *locus of decision-making was teacher dominated (STAM 20A)*. In this class, teaching aids were displayed but they were not *integrated* *with the content (STAM 21A).* Lastly, no *examples of students' work were displayed (STAM 22A).*

4.12.2.5 Summary

In this lesson on the perpendicular bisector of lines, a description of the lesson was given followed by an analysis of the examples from the lesson guided by STAM descriptors discussed in Chapter 3. Out of the 22 STAM descriptors, all parts of this lesson were identified as being didactic.

4.13 Overall Summary

This chapter presented the results of the study of investigating the status of mathematics teaching in three township secondary schools. Each of the lesson was analysed using the framework of Gallagher and Parker (1995). The teaching into didactic, transitional and conceptual approaches have been classified and summarised in Table 4.1. The adapted framework of Gallagher and Parker (1995) is shown in Chapter 5 to provide responses to the research questions of the study.

On the whole, the status of the teaching styles of those township mathematics teachers was identified as being primarily didactic. However, some parts of the lessons exhibited characteristics of transitional teaching (14 descriptors) and conceptual teaching (one descriptor). Examples from the lessons were given to support the arguments for the lessons being classified as didactic, transitional or conceptual. However, those parts of lessons that were identified as transitional were in a minority. The next chapter presents the synthesis of the analysis of Chapter 4.

Table 4.1 Summary of analysis using the framework of Gallagher & Parker (1995)

Teacher	Content				Teachers' actions and assessment							Students' actions					Resources and Environment					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Mr. Timba	D	D	D	D	D	D	T	D	D	D	T	D	D	D	D	D	D	D	D	D	D	D
Ms. Mogotse	D	D	D	D	D	D	D	D	D	D	D	T	D	D	D	D	D	D	D	D	D	D
Ms. Makola	D	D	D	D	D	T	D	D	D	D	D	T	D	D	D	D	D	D	D	D	D	D
Mr. Mosotho	D	D	D	D	D	D	D	D	D	D	D	T	D	D	D	D	D	D	D	D	D	D
Mr. Lekgau	D	D	D	D	D	D	D	D	D	D	D	D	T	D	D	T	D	D	D	D	D	D
Mr. Nare	D	D	D	T	D	T	D	D	D	D	D	D	D	T	D	D	D	D	D	D	D	D
Mr. Mosotho	D	D	D	D	D	D	D	T	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Mr. Muntu	D	D	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Mr. Naka	D	D	T	D	D	D	D	D	D	D	D	T	D	D	D	D	D	D	D	D	D	D
Mr. Nare	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Mr. Naka	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Mr. Muntu	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D

Content (4 rows)

1.Structure of content

2.Use of examples

3. Limits, excerptions, and multiple interpretations

4. Processes and history of maths

Teachers' actions and assessment (7 rows)

5. Teaching methods

6. Labs, demonstrations, and hands on activities

7. Teacher student interaction

8. Teacher questions

9. Kinds of assessment employed

10. Uses of assessment beyond grading

11. Teacher's responses to student ideas

Students' actions (5 rows)

12. Writing and other representations of ideas

13. Students questions

14. Student -student interaction

15. Student initiated –activity

16. Student understanding of teacher expectations

Resources (3 rows)

17. Richness of resources

18. Uses of resources

19. Access to resources

Environment (3 rows)

20. Locus of decision-making

21. Teaching aids displayed

22. Students' work displayed

CHAPTER 5

SYNTHESIS, RECOMMENDATIONS AND CONCLUSIONS

5.0 Introduction

This chapter concludes the study by addressing eight areas. Section 5.2 introduces the adapted framework for the study; Section 5.3 provides a synthesis of the results in the form of addressing the research questions of the study. Section 5.4 presents general observations and Section 5.5 puts forward recommendations for In-service of mathematics teachers in township schools. Section 5.6 identifies limitations and Section 5.7 draws implications for further research. Section 5.8 is the conclusion and Section 5.9 is a summary of the thesis.

5.1 The adapted framework

The framework of Gallagher and Parker (1995) was adapted for this study in relation to answering the five research questions related to content, teaching, assessment practices, interactions between the teacher and the student and resources availability. This adapted framework is shown in Table 5.2. Next, each framework is described as well as how it was adapted for this study to analyse the 12 lessons. The coding, for example STAM 1A, is used to refer to the relevant characteristics for each lesson that was analysed in Chapter 4.

5.1.1 Content knowledge

Using the adapted STAM framework (Gallagher & Parker, 1995), the content of teaching was characterised as *didactic teaching* when:

- The structure of the content is in the form of factual content and factoids. (STAM 1A)
- There are no examples or connections to (a) real world events, (b) related ideas, or (c) key ideas of the subject. (STAM 2A)

Table 5.1 Summary of analysis using the framework of Gallagher & Parker (1995) adapted for this study

Teacher	Content				Teaching					Assessment practices			Interaction between the teacher and the student						Resource availability			
	1	2	3	4	5	6	8	20	21	9	10	11	7	12	13	14	15	16	17	18	19	22
Mr. Timba	D	D	D	D	D	D	D	D	D	D	D	T	T	D	D	D	D	D	D	D	D	D
Ms Mogotse	D	D	D	D	D	D	D	D	D	D	D	D	D	T	D	D	D	D	D	D	D	D
Ms. Makola	D	D	D	D	D	T	D	D	D	D	D	D	D	T	D	D	D	D	D	D	D	D
Mr. Mosotho	D	D	D	D	D	D	D	D	D	D	D	D	D	T	D	D	D	D	D	D	D	D
Mr. Lekgau	D	D	D	D	D	D	D	D	D	D	D	D	D	D	T	D	D	T	D	D	D	D
Mr. Nare	D	D	D	T	D	T	D	D	D	D	D	D	D	D	D	T	D	D	D	D	D	D
Mr. Mosotho	D	D	D	D	D	D	T	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Mr. Muntu	D	D	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Mr. Naka	D	D	*T*	D	D	D	D	D	D	D	D	D	D	*T*	D	D	D	D	D	D	D	D
Mr. Nare	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Mr. Naka	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Mr. Muntu	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D

Content (4 rows)

1.Structure of content

2.Use of examples

3. Limits, excerptions, and multiple interpretations

4. Processes and history of maths

Teaching (5 rows)

5. Teaching methods

6. Labs, demonstrations, and hands on activities

8. Teacher questions

20. Locus of decision-making

21. Teaching aids displayed

Assessment practices (3 rows)

9. Kinds of assessment employed

10. Uses of assessment beyond grading

11. Teacher's responses to student ideas

Interactions (6 rows)

7. Teacher student interaction

12. Writing and other representations of ideas

13. Students questions

14. Student -student interaction

15. Student initiated –activity

16. Student understanding of teacher expectations

Resource availability (4 rows)

17. Richness of resources

18. Uses of resources

19. Access to resources

22. Students' work displayed

- The limits, exceptions, and multiple interpretations are oversimplified so that the limits or exceptions within content are not presented. Many statements are absolutes without qualifiers. (STAM 3A)
- Processes and history of mathematics are not discussed and there is no mention of how we know. Mathematical method is presented separately as static or algorithmic approach. (STAM 4A)

Table 5.2 The framework of Gallagher and Parker (1995) adapted for this study

Content knowledge (4 rows)

1. Structure of content
2. Use of examples
3. Limits, excerptions, and multiple interpretations
4. Processes and history of mathematics

Teaching (5 rows)

5. Teaching methods
6. Hands on activities
8. Teacher questions
20. Locus of decision-making
21 Teaching aids displayed

Assessment Practices (3 rows)

9. Kinds of assessment employed
10. Uses of assessment beyond grading
11. Teacher's responses to student ideas

Interactions between the teacher and the students (6 rows)

7. Teacher student interaction
12. Writing and other representations of ideas
13. Students questions
14. Student-student interaction
15. Student initiated–activity
16. Student understanding of teacher expectations

Resource availability (4 rows)

17. Richness of resources
18. Uses of resources
19. Access to resources
22. Students work displayed

In *transitional teaching*, content using the STAM framework is characterised by the following features:

- Content tends to be descriptive with concepts and factoids given equal emphasis. (STAM 1B)
- There is use of examples and/or related ideas separate from other pieces of content. (STAM 2B)
- Some limits, exceptions, and alternate interpretations are included, but are not integrated with other content. (STAM 3B)
- No explicit mention is made of how we know. Processes of mathematics such as observation and inference are not integrated with content. (STAM 4B)

In *conceptual teaching*, content is characterised using the STAM framework by the following features:

- Content tends to be explanatory with conceptual content organised around key ideas. (STAM 1C)
- Use of examples and connections are made by the teacher to (a) real world events, (b) related ideas and (c) key ideas of the subject. (STAM 2C)
- Limits, exceptions, and alternate interpretations are presented as part of the content. (STAM 3C)
- "How we know" is included in the content. The teacher integrates processes of mathematics with concepts. (STAM 4C)

5.1.2 Teaching

Using the adapted STAM framework (Gallagher & Parker, 1995), the teachers' methods are characterised as *didactic teaching* by the following features:

- One or two teacher-centred methods predominate. (STAM 5A)
- Demonstrations and hands-on activities are not used. (STAM 6A)
- Teacher's questions call for factual recall. (STAM 8A)
- The locus of decision-making is teacher dominated. (STAM 20A)

- Few teaching aids are displayed and may not be integrated with the content. (STAM 21A)

In *transitional teaching*, the teachers' methods using the STAM framework are characterised by the following features:

- Three or four teacher-centred teaching methods include some hands-on activities. (STAM 5B)
- Some demonstrations or hands-on activities which are either overly directed (cookbook) or undirected (e.g., exploration without follow - up). (STAM 6B)
- Teachers' questions are directed towards mathematical ideas, not towards connections or applications, and they do not build on students' responses. (STAM 8B)
- Little sharing of decision-making with students. (STAM 20B)
- Some teaching aids are displayed and may not be related to the content. (STAM 21B)

In *conceptual teaching*, the teachers' methods using the STAM framework are classified by the following features:

- There is a rich repertoire of teacher-centred methods, including hands-on activities. (STAM 5C)
- Many demonstrations or hands-on activities are conceptually focused. Answers are generally known ahead of time. (STAM 6C)
- Teachers' questions are directed towards knowledge of mathematical concepts and their connections and applications but they do not build on students' responses. (STAM 8C)
- Some sharing of decision-making with students about use of time. (STAM 20C)
- Many teaching aids related to the content are displayed. (STAM 21C)

5.1.3 Assessment practices

In the same way, using the adapted STAM framework (Gallagher & Parker, 1995), the kind of assessment used is characterised as didactic teaching by the following features:

- Assessment is in the form of tests and quizzes only. (STAM 9A)
- There are no uses of assessment beyond grading. (STAM 10A)
- The teacher disregard students' ideas about subject matter. (STAM 11A)

In *transitional teaching,* assessment is characterised using the STAM framework by the following features:

- Occasional checking of students' knowledge in addition to tests and quizzes. (STAM 9B)
- Checking students' knowledge. (STAM 10B)
- The teacher may accept all students' ideas and also view students' unmathematical ideas as oddities. (STAM 11B)

In *conceptual teaching*, assessment is classified using the STAM framework by the following features:

- Frequent checking of students' knowledge in addition to tests and quizzes. (STAM 9C)
- Checking students' knowledge and preplanning. (STAM 10C)
- Teacher investigates students' ideas about subject matter and works to alter "unmathematical" ideas. (STAM 11C)

5.1.4 Interactions between the teacher and the students

Similarly, using the adapted STAM framework (Gallagher & Parker, 1995), teacher-student interactions are characterised as *didactic teaching* by the following features:

- Little-teacher student interaction about subject matter (chalk and talk). (STAM 7A)

- Writing and other representations of ideas are not used and only short answers from students predominate. (STAM 12A)
- There are few students' questions. (STAM 13A)
- Student–student interaction is rare or nonexistent. (STAM 14A)
- Students rarely volunteer examples or analysis. (STAM 15A)
- Students are passive or ignore the teacher's procedures. (STAM 16A)

In *transitional teaching*, teacher-student interactions are characterised using the STAM framework by the following features:

- Teacher–student interaction about correctness of students' ideas about unconnected facts. (STAM 7B)
- Writing and other representations of ideas are rarely used. Most are reconfigurations of information provided. (STAM 12B)
- Students' questions clarifying procedures dominate. Some questions ask for clarification of terminology or repeat of information. (STAM 13B)
- Some student-student interaction, mostly about procedure. (STAM 14B)
- Students volunteer a few examples, but connections to class activities may be weak. (STAM 15B)
- Students show confusion over procedures. (STAM 16B)

In *conceptual teaching*, the teacher–student interaction is characterised using the STAM framework as:

- Teacher-student interaction about correct-ness of students' knowledge of conceptual content. (STAM 7C)
- Several forms of writing and other representations of ideas are used. Most are reconfigurations of information provided. (STAM 12C)
- Student questions focus on clarification of meaning related to specific concepts or procedure. (STAM 13C)
- Some student–student interaction about procedure. Some about articulating mathematical ideas correctly. (STAM 14C)
- Students volunteer some examples related to class activities. (STAM 15C)
- Students accept procedures and role. (STAM 16C)

5.1.5 Resource availability

Using the adapted STAM framework (Gallagher & Parker, 1995), the availability of resources is characterised as *didactic teaching* when:

- Resources are little beyond single text or format. (STAM 17A)
- Students look at, but do not actively use resources and when resources are not related to content. (STAM 18A)
- Access to resources is controlled by the teacher. (STAM 19A)
- Few examples of students' work are displayed. (STAM 22A)

In *transitional teaching*, resources are characterised using the STAM framework by the following features:

- Text and small number of resources, including some hands-on. (STAM 17B)
- Resources are not related to content. (STAM 18B)
- Access to resources controlled by the teacher. (STAM 19B)
- Students' work displayed is typically similar for all students. (STAM 22B)

In *conceptual teaching*, resources are characterised using the STAM framework by the following features:

- Multiple resources, i.e. visual aids, videos, manipulatives, technology, or people. (STAM 17C)
- Resources are related to content and illustrate ideas. (STAM 18C)
- The teacher controls access to resources, but there is some discussion of access with students. (STAM 19C)
- Some variations in students' work are displayed. (STAM 22C)

5.2 Synthesis of results

This section provides a synthesis of the results based on the analysis of teachers' lessons using STAM in Chapter 4. The summary of the findings for each of the five research questions is an attempt to examine the problem investigated, namely, the status of mathematics teaching and learning in township schools. A detailed description of each lesson was given in chapter 4. Each lesson description was divided into parts and analysed using the STAM framework to characterise the teaching according to didactic, transitional or conceptual descriptors. A summary for the Secondary Teaching Analysis Matrix-Mathematics (STAM-Mathematics) (Gallagher & Parker, 1995) used to analyse 12 Grade 10 to 12 mathematics teachers' lessons in township schools was presented in Table 4.1.

5.2.1. Summary of findings for Research Question 1: What is the status of the teachers' content knowledge?

Content

The content was expressed by four aspects namely, the structure of the content (STAM 1), the use of examples (STAM 2), limits, exceptions and multiple interpretations (STAM 3), and processes and history of mathematics (STAM 4). On the whole, all the lessons were identified as being conducted in a didactic manner. However, with respect to the descriptor (STAM 3BC), Mr.Muntu's lesson [Section 4.8 Part 1] was characterised as having traces of conceptual teaching and Mr Naka's lesson [Section 4.9 Part 2] as having minimal attributes of transitional teaching (STAM 3AB). Also, Mr Nare's lesson [4.6 Part 2] was characterised as transitional (STAM 4AB).

From this result, changes towards transitional and conceptual teaching are evident when the content is presented by the teacher to include cognitive approaches. Examples of these cognitive approaches are when the teacher would ask questions like, " Look at these steps and tell me where you did not understand? [4.6 Part 2] or when the teacher checked whether learners understood [4.8] or used some alternative interpretations of the content [4.9 Part 2].

The use of the STAM descriptors to analyse the content in the lessons enabled some of the following specific issues pertaining to the teaching and learning of mathematics in township schools to surface.

Teacher content knowledge

Some mistakes were found in the chalkboard working of the teachers and their general command of the subject matter was often lacking [see 4.5 Part 1; 4.3 Parts 1 and 2; 4.4 Part 2]. This low level of conceptual understanding concerning teachers of mathematics in South Africa is consistent with research that has been reported elsewhere (Glover & King, 2000; Taylor & Vinjevold, 1999).

Subject matter coverage

A closer look at the number of problems done in one lesson indicated that on average two problems were completed or attempted in a lesson period as can be seen in Table 5.2. Three lessons were observed in Grade 10 four lessons in Grade 11 and five lessons in Grade 12.

Table 5.3 Number of problems per lesson for each grade level

Grade	Number of Problems per Grade				
10	3	1	4		
11	1	2 (3)*	3	1 (3)*	
12	3	3	3(5)*	2 (6)*	1(2)*

*The numbers in brackets indicate problems that were given as homework or class work.

One problem done in Grade 11 was not completed in class [4.1]. In the case where homework problems were not completed in one period, these problems were carried over into the next period so that they could be completed. However, taking more time to complete each problem could impact on the syllabus completion for the Grade. For example, if the subject content prescribed for a particular grade is not completed, this is likely to result in learners having gaps of knowledge carried over in other sections of the work or in the next class. For example, if learners have not mastered how to factorise the difference of two squares and a trinomial, they might have a problem with applying the same techniques in other sections like, finding the limit in the problems of this kind.

$$\lim_{x\to 2}\frac{x^2-4}{x+2} \text{ and } \lim_{x\to 2}\frac{x^2-3x-10}{x+2}$$

Teachers' pedagogical content knowledge

In the lessons observed, there were problems identified with teachers' content knowledge and many of the teachers exhibited limited pedagogical skills [4.5 Parts; 4.4; 4.6]. There was little evidence of effective pedagogical content knowledge except for Mr Muntu [4.8] where an attempt was made to use illustrations as a way of representing and formulating the subject such that it can be comprehensible to others (Shulman, 1986).

5.2.2 Summary of findings for Research Question 2: What is the status of the teachers' teaching?

Teaching

The teaching was represented by five aspects namely, the teaching methods (STAM5), hands-on activities (STAM6), the locus of decision-making (STAM20), teacher questions (STAM8), and teaching aids being displayed (STAM21). On the whole, the teaching was analysed as being didactic with one or two teacher–centred teaching styles predominating. However, the teachers exhibited minimal moves towards transitional teaching on only two descriptors (STAM 6AB [4.3 Part 2; 4.6 Parts 2 & 3] and STAM 8AB [4.7 Part 2]) when the teaching was transitional. This was when Mr Nare attempted to use hands-on activities and also when questioning strategies were in ways that directed students towards encouraging metacognitive skills. For example Mr. Nare said, "Look at these steps and tell me where you did not understand?" These metacognitive skills of asking and reflecting help students to be consciously aware of themselves as problem solvers and helps to monitor and control their mental processing (Baird & White, 1996; Bruer, 1993). Some of the specific issues relating to the teaching method that were identified during the analysis are now discussed.

Homework

Homework seemed to be one of the most important teaching strategies used by the teachers. In almost all the analysed lessons, every lesson started with homework correction which was carried out in two ways, either by inviting learners to come to the chalkboard and work out problems [4.2 Part 1] or the teacher simply working out these problems on the chalkboard [4.2 Part 2]. As the analysis revealed, almost all the learners who were called forth to work out problems on the chalkboard were not able to complete the problem. Subsequently, the teacher would take over and work out these problems without asking the learners' about their specific difficulties or pointing to the difficulty area. The learners' attempts were simply wiped out from the chalkboard without asking what it was they could not do [4.2 Parts 3 & 4; 4.5 Part 5].

In other instances, without even asking learners which difficulties they encountered when doing the homework problems or without saying anything, the teacher would start writing solutions to these homework problems on the chalkboard and the learners would copy down the answers [4.9 Part 2].

In the light of this discussion on homework, since homework plays such a major role in the learning and teaching of mathematics in these schools, this is an aspect that needs to be investigated on how best to handle this activity to better impact on student learning.

Unproductive questioning

Part 4 of the lesson on Simultaneous equations [4.1] shows that the teacher spent six minutes asking questions that were unproductive when leading learners towards recalling the quadratic formula, for example, Mr Timba said: "I am going to ask each one of you. Have you forgotten it? Don't you know? (The teacher pointed a chalk at the board for about one minute waiting for learners to respond so that he could write the formula. You wrote it in the assignment. Have you forgotten it? Let me hear you. Do you also know it? Have you also forgotten?" In Part 3 of the lesson on Limits of functions, when learners were solving class-work problems [4.4], Mr Mosotho said: "Are you finishing? It does not seem so. What are you doing with a calculator? Don't you know 3 x 2? We are left with 5 minutes". These questions do not lead to thought-provoking processes. They did not encourage problem solving strategies as suggested by Polya (1973) that " ... if you solve it by your own means, you may experience the tension and enjoy the triumph of discovery"(p.v).

Chorus responses

Chorus responses characterised almost all of the analysed lessons. It was common to have teachers pose questions and answer them alone or together with the learners [4.8 Part 1; 4.12 Part 1 & 4]. When the teacher posed a question, all the learners answered, or some learners answered [4.1 Part 1]. When this happened, it was difficult to know whether all the learners had the same level of understanding of the subject matter or whether they followed the lesson without reflecting upon what was being said. In all the analysed lessons, teachers did not probe the learners to respond individually [4.8 Part 2].

Similarly, a study on language practices in mathematics classrooms in South Africa revealed that chorusing featured strongly in secondary schools as compared to primary schools (Setati, 1998). Setati speculated that though it was not teacher initiated, it seemed to be a means of assuring the teacher that everyone still followed instruction. Based on my observations in these lessons, although chorus responses did not reveal learners' understanding of the subject matter, they were used as a way of assuring the teacher that learners are paying attention to instruction. Furthermore, the teachers seemed to expect students to respond that way since they did not attempt to probe students to respond individually.

Group-work discussions

Several classes had learners seated in groups although during class teaching these groupings did not seem to be leading to intellectual debate [4.3 Part 3; 4.6 Part 3 & 4]. For example, in Ms Makola's lesson, each of the groups, except for one which had no calculator, had only one calculator between them. The group discussions seemed to be more on learners seeking help on how to operate the calculators and less on the mathematical ideas under discussion. In Mr Nare's lesson, for example, the learners had different calculators and were seen moving from one group to another, trying to figure out how they could solve problems with calculators that they borrowed from friends in another class.

The textbook

In almost all the analysed observed lessons, learners normally did not have textbooks with them during the lesson. Consequently, the teacher spent much time writing problems on the chalkboard for learners to copy and those problems could easily be copied wrongly [4.2; 4.3; 4.4; 4.5; 4.6; 4.12; 4.9]. Concerning the homework in the absence of the textbook, it was also revealed that one teacher Mr. Naka [4.11 Part 3] would read out problems for learners. As I was taking down field notes, I was struggling to catch up with the writing of the problems since they were read aloud only once. In some instances, where the textbooks provided by the school were to be shared, it was difficult for learners who shared the book to do the homework [4.7 Part 3].

A common phenomenon was for the learners to frequently turn the pages of their notebooks. I suppose this was done to check how previous work was done or to check for a formula since their notebooks were the main point of reference in the absence of the textbook in class. Learners tended to write notes given by the teachers into the back of their notebooks. This turning of pages might also be a result of searching for examples on how the problems were supposed to be solved.

Teacher talk

In almost all the analysed lessons, the teacher was the one talking all or most of the time [4.6 Parts 2 & 3; 4.9; 4.8; 4.12]. Students normally listened attentively to the teacher and seemed to depend much on the spoken word of the teachers because they did not bring their textbooks during instructional periods [4.8]. It was also revealed that the teachers did not give time for learners to complete their chalkboard problems. Further, the teachers did not guide learners to think through what they wrote in order to help and finish solving the problem [4.4 Part 2; 4.2 Parts 2 & 3].

Copying

One common characteristic was for learners to copy worked out exercises from the chalkboard. There was no time for reflection when learners were copying most of the time. These practices have been observed in Black mathematics and science classrooms in South Africa (Jita, 2002). However, it seems that in these three township schools, copying might be a result of learners not being in possession of the textbook in class.

Writing down answers

The idea of giving answers prior to learners actually working out these problems has been evident in some of the lessons [4.4 Parts 3; 4.6 introductory part of the lesson]. This might be a good way of encouraging learners to work out solutions independently, but as seen in the lessons this approach did not end up in fruitful results. The teacher ended up solving the problems since the students seemed not to know how to work them out. This approach to problem solution could be linked to the absence of the textbook in the classroom to which learners could refer.

Explanations

The role of the teacher is to provide learners with understandable explanations. The written and spoken forms of the teachers' explanations are fundamental to learners understanding of mathematical concepts (Zuzovsky & Tamir, 1999). From the learners' utterances, learner behaviour and the researchers' reflections, there were indications that might suggest need for further clarification of concepts from the teacher which were not provided [4.5 Part 2]. For example, observed learner behaviours included turning pages of notebooks [4.11 Part1] and facial expressions.

Mr Nare was showing learners how to determine the x- intercept and his chalkboard work was as follows:

$$y = 2x + 1$$
$$0 = 2x + 1$$
$$-2x = 1$$
$$x = -\frac{1}{2}$$
$$x = -0{,}5$$
$$x(-0{,}5;0)$$

One learner asked where the 5 in $-0{,}5$ came from. Perhaps the teacher assumed that the learners would know that $-\frac{1}{2}$ was equal to $-0{,}5$. But the representation of the x intercept as x (- 0,5; 0) could also be confusing because it is not a standard notation for x- intercept [4.10 Part 2].

In the lesson on Geometric sequences, for the explanations on how to determine the 5^{th} and the 8^{th} terms in Part 1 of the lesson, it was unclear whether to write $T_8 = ar^{7-1}/^{8-1}$ to determine the 8^{th} term or whether the 5^{th} term was determined by the equation $T_5 = ar^{4-1}$ [Part 2] or $T_5 = ar^{5-1}$.

In my reflections as the teacher was explaining, I commented: "I thought to myself that he could have written the formula first for the benefit of the learners. I wondered whether learners were following. I felt that he should always write the values of *a* and *r*".

Part 2 of the same lesson illustrated learners' difficulties, as for example some stating, 'we don't understand' [4.5 Parts 2, 3 & 6], and my reflections, 'some learners looked puzzled' [4.5 Part 6], and 'some learners mumbled' [4.5 Part 3].

The following example which was copied from the learner that I was sitting next to during the lesson on changing the subject of the formula [4.4; Section 4.2.1.1] shows that the learner did not know how to change the subject of the formula to *r*.

$$e = \frac{E}{R + r}$$

$$\frac{R \times E}{R + r} = e$$

$$\frac{r \times E}{r} = \frac{e}{r}$$

$$r = \frac{e - R}{E}$$

Lesson planning

A closer examination of the lessons described in chapter 4 showed the amount of subject matter covered in a period and some mistakes those teachers made in the presentations of the lessons [4.5, 4.9 Part1]. When the bell rung in the middle of an explanation, lessons ended abruptly because there was not enough time to work out the problem. The abrupt ending of lessons in some cases was caused by unproductive questioning strategies [4.1 Part 4] and teacher talks that did not relate to the lesson topic [4.4 Part 3]. Other reasons might be attributed to late coming as there was a tendency of both teachers and learners to come late to class. These problems relate to aspects of professional attitudes that have been found to be prevalent among teachers in South Africa and may imply a need for proper planning of the lesson procedures (Grayson & Ngoepe, 2003; Grayson et al., 2001).

Mistakes in lesson presentations and the bell ringing in the middle of the teaching sequence might suggest a need for the teachers to come to class with written out lesson plans, with worked out problems indicating time divisions for each activity dealt with in a lesson. For example, in a 30 minutes lesson, there is need to divide time say 5 minutes for the introduction, 15 minutes for activities and 10 minutes for the lesson conclusion. In the case where the lesson started 10 minutes late, lesson activities cannot be completed in that limited time.

Classroom routines

Each of the lessons followed a pattern of classroom routines familiar to both teacher and students. For example, in five lessons, the daily classroom routines were correction of the previous day's homework, followed by class work to continue the topic that was being discussed. At other times, a new topic was introduced to complete the lesson series of a particular topic. Usually the lesson ended with a set of homework problems which were written on the chalkboard or read out.

Classroom discipline

In several classes, learners were doing other work not related to mathematics [4.9]. During class periods, several learners were moving from one desk to another asking for stationery items from other learners. For example, learners moved to a friend's desk to do a calculation, take a friend's book and copy out a problem, to see how others solved the problem, or get help with the operation of the calculator [4.6] get a pencil, rubber or tipex or exchange tops of lids of Vaseline or Vicks containers to draw circles [4.3; 4.8;]. Perhaps the teacher saw that it was acceptable to do this because learners would not otherwise have stationery items. Some learners were sleeping in class on desks [4.2]. As observed, there was a general indication that teachers did not cope with learners' poor behaviours in the lesson.

Language of instruction

In most of the lessons, both the learners and teachers were communicating in Setswana. The South African classroom practices have been found to be characterised by multilingualism, and code switching was common (Adler, 1998, 2001; Setati, 1998). However, it is not known at this stage what impact this might have had on the teaching and learning of mathematics in these schools. Studies such as that by Adler (1998) have raised the dilemma of the impact that this language issue might have on learners' understanding of Grade 12 examinations which are written through the medium of English.

5.2.3 Summary of findings for Research Question 3: What is the status of the teachers' assessment practices?

Assessment Practices

The state of assessment practices was characterised as being didactic by, kinds of assessment employed (STAM 9), uses of assessment beyond grading (STAM 10), and teachers' responses to student ideas (STAM11). It was only with (STAM 11AB) for teachers' response to students' ideas [4.1. Parts 1 & 2) that the teaching was transitional when Mr. Timba accepted students' responses to the questions that were posed in the process of solving a problem. Specific issues relating to assessment from the lessons follow.

Group assessment

Group assessment seemed to be one of the common forms of assessment that the teachers used to gain information about learner performance. While it might be one of the forms of assessment encouraged in Outcomes Based Education (OBE), in the analysed lessons, this approach seemed to be an ineffective form of assessing learners. While groups of learners wrote assignments on book pages [4.3 Part 4], it seemed that only the academically able learners in a group wrote the problems [4.3 Part 4; 4.1 Introductory section]. This lack of attention by some learners in the groups could impact negatively on learners when they had to write the tests and examinations.

Portfolio work

Concerning portfolio work, it seemed that even though there were prescriptions on how portfolio assessment was supposed to be handled from the Department of Education documentation, its implementation was still not clear [4.3 Part 4]. The work for the students' portfolios comprised exercises that were the same as those for homework or class work. I observed that the administration of portfolio work was such that learners were given problems, which they did in groups during class and had to complete within 15 minutes and hand over to the teacher, but this work was virtually done by one able learner. My expectation was that portfolio work, which forms part of Continual Assessment (CASS) that counts towards 25% of the final mark of a student at Grade 12, would be on work that was more or less at the same level of difficulty as the examination (Department of Education, 2002). However, having observed how portfolio assignments were written, individual assessment would have benefited learners better and the teacher would know what the learners were capable of achieving. During the observation period, no tests were administered.

5.2.4 Summary of findings for Research Question 4: What is the status of the interaction between the teachers and the students?

Interactions between the teachers and the learners

Interaction between the teacher and the learners were recognised by 6 STAM items namely, teacher-student interaction (STAM 7), writing and other representations (STAM 12), student questions (STAM 13), student-student interaction (STAM 14), student initiated activity (STAM 15), and student understanding of teacher expectations (STAM 16).

With several STAM descriptors, the interactions between the teacher and the students were identified as having exhibited small traces of transitional teaching with the descriptors for teacher-student interaction (STAM 7AB) [4.1 Parts 2 & 4], student questions (STAM 13AB) [4.5 Part 5], student interaction (STAM 14AB) [4.6 Introduction section], writing and other representations of ideas (STAM 12AB) [4.2 Part 2; 4.3 Parts 1, 4 & 5; 4.4; 4.9 Parts 1 & 3], and student understanding of the teacher's expectations (STAM 16AB) [4.5 Part 7]. It seemed that teacher-student interactions indicate a move towards transitional teaching when the teacher attempted to ask questions that led to students correcting their ideas [4.1], when the teacher gave learners an opportunity to ask questions for clarification of procedures about problem solutions [4.5], and when student-student interactions were about problem solutions [4.6]. However, on the whole, teacher-student interactions were didactic. The following general issues were revealed.

Engagement of students

Calling students to come forward to the board to solve a problem seemed to be one of the prominent methods that the teachers used to engage or involve learners in the learning of mathematics. In almost all the analysed lessons, students who were called to the chalkboard to work out problems ended up not getting the right answer [4.2 Introductory section of the lesson, Part 1,2 and 3; 4.4 Part 2]. In all cases, the learners were called to solve problems that were given for homework or class work. Most of these learners attempted to work out these problems without talking or saying what they were doing.

Student-student interactions

In almost all classes, learners were seated in groups, but student-student interactions seemed not to involve intellectual debate but were in the form of learners seeking explanations on how calculations were arrived at. Despite, Outcomes Based Education (OBE) in Curriculum 2005 in South Africa encouraging learners to be active participants in the learning environment, this participation seemed lacking. Slavin (1996) suggests that learners learn better by talking themselves through difficult problems because as they talk, their thoughts are clarified.

Teacher-student interaction

In all 12 lessons, the teacher was the one talking all the time and there was no active interaction with learners and also there was no active questioning [4.8 Part1]. Instead, the interaction was dominated by chorus responses [4.1; 4.8 Part 1; 4.12 Part 2]. Learners who sat towards the front seemed to be inclined to have more interactions with the teacher and these seemed to be the more academically able learners [4.2; 4.10 Section 4.10.1.1]. Perhaps the absence of the textbook in the class could account for little teacher-student interaction since it seemed that learners did not do further exercises than the ones given by the teacher.

Chastising students

A common occurrence experienced were instances of teachers chastising learners by saying things that did not relate to the lesson procedures [4.1 Part 4; 4.4 Part 3]. For example when Mr Mosotho said: "You will regret this. Do not forget what you are doing. The majority of you will regret this. I feel pity for you. You say this class is yours and mine. Not long you will be crying. Write. Are you writing or are you talking?" [4.4 Part 3]. This chastisement happened when learners were solving problems and this might have disturbed the learners thinking.

5.2.5 Summary of findings for Research Question 5: What is the status of the resource availability in the schools?

Resource availability

Four features expressed resource availability in the schools: richness of resources (STAM 17), uses of resources (STAM 18), access to resources (STAM 19), and students' work displayed (22). All the lessons were characterised as didactic in terms of resources (Table 5.12). Specific issues related to resources availability for the lesson follow.

Teacher material

The policy and provision of learning materials by the Department of Education regards adequate learning support materials as essential to the effective running of an education system and asserts that these materials are an integral part of curriculum development and a means of promoting both good teaching and learning (Taylor & Vinjevold, 1999). The definition of learning support material according to the Department of Education includes a wide range of texts, resources and equipment. These resources encompass more than just textbooks and include print-based and electronic materials. Print sources include notes, documents, published textbooks, workbooks, reading schemes, newspapers, magazines, supplementary readers, teacher guides and reference books, while electronic resources include transparencies, slides or sound presentations.

However, in township schools the resources for teaching and learning mathematics were the chalkboard and the teachers' textbooks. The teachers lacked mathematical instruments to be used to demonstrate positions of points on lines or even to draw geometrical figures and calculators [4.8 Part 0; 4.1 Part 1]. Only one classroom had handmade charts showing mathematical pictures and drawings [4.8 Section 4.8.1.1]. Although, mathematical information is plentiful in newspapers and magazines, these were not displayed or incorporated in any lesson observed.

Learner material

Even though textbooks are given to learners, most learners did not bring the textbooks to the classroom. In the lessons where calculators had to be used for instruction, the teachers did not have their own calculators with them but instead borrowed a calculator from the learners [4.3; 4.6 Part 3 & 4]. While, the learners had notebooks with them, as revealed earlier, most did not have stationery such as erasers, pencils and rulers.

The availability of teacher and learner materials has great implications on how teachers structure their instructional practices. For example, disruption to the lesson occurred when the teacher had to send a group of learners away to fetch calculators [4.6 Introduction section]. One complication is that these calculators are different models and learners do not know how to operate them and this imposes a greater demand on the teacher to help them understand how the calculators work even before dwelling on the mathematics that has to be learned using the calculators. These calculators may compound the problem in the test or examination room and may cause learners not even to finish within the examination timeframes because they would still be trying to figure out how to use these calculators so they can solve problems [4.6 Parts 3 & 4; 4.3 Part 2].

5.3 General observations

This section highlights some of the general observations that were made by me during the observation period in the township schools.

5.3.1 Unprofessional attitudes

There were several incidences in almost all the schools of teachers coming to class late for lessons by 10-15 minutes, leaving the learners unattended for this time during class periods. Other instances involved teachers showing reluctance to go to class and sitting in the staff room or standing in the foyer on their way to class. In the last period of the day there was almost no teaching going on in school T: The learners were talking loudly in the classes and were outside on the veranda.

5.3.2 Arriving late and missing class

In the first period, many learners arrived late to school. The school authorities had a tendency of keeping a security guard at the gate which was locked at the school starting time of either 7h30 or 8h00. Consequently, many of the learners would be standing outside the gate at the start of the first lesson of the day.

5.3.3 Attempts at disciplining students

At School K learners who arrived late were beaten as they entered the school gate. The teachers did this in an effort to discipline the learners to arrive on time for lessons. Corporal punishment was abolished in South Africa with the purpose of providing a uniform system of schools administration in the post-apartheid period through the constitution of the South African Schools Act (SASA) (1996c). According to SASA, any person who contravenes this act is guilty of an offence and liable to a sentence that could be imposed for assault. However, the learners were beaten despite the Department of Education policy of no corporal punishment. This might be a result of the act not recommending alternative ways for teachers to administer punishment.

5.4 Recommendations for in-service of mathematics teaching in township schools

A synthesis of the findings of the lessons which were analysed using the 22 STAM descriptors to investigate the status of mathematics teaching and learning in three South African township schools was done in terms of the content, the teaching methods, assessment, interactions and the resources used during the lessons. The STAM descriptors were used to characterise teaching to find out whether the teaching in township schools was didactic, transitional or conceptual. The STAM descriptors clearly identified mathematics teaching in township schools as being didactic.

In order for teachers to transform their teaching from didactic through transitional to conceptual teaching, these teachers will need a different form of in-service that is rooted and directed by the kind of situation in which they find themselves.

In the light of these eight South African mathematics teachers (and others) having being disadvantaged by the Bantu Education system in the apartheid era and the reforms post 1994, in-service programmes should aim at addressing the problem areas as identified by the STAM descriptors. These areas relate to content, teaching, interactions between the teacher and the students, assessment practices, and resources that have been guided by the research questions of the study and the classroom issues that surfaced through the use of the STAM. Consequently, based on the synthesised results, the following recommendations are made.

5.4.1 Nature of the in-service sessions

Pertaining to organising the in-service sessions of the teachers, it is suggested that the in-service be at a central location that would be decided in conjunction with the teachers. In the case of the teachers in this study, this location may be at UNISA or at an identified location in the township where renting of the premises is at minimal cost. Ownership of the in–service programme should involve the teachers and the in-service providers so that the teachers feel that it is their in-service program and not a top-down innovation (Thair & Treagust, 1997). A meeting or training schedule should be drawn up in collaboration with teachers concerning the number of weeks of training and at suitable times, whether this is Saturday, after school or in the school holidays. Teachers need to be encouraged to participate in the in-service sessions and informed that they will help to change their practice and hence make their teaching more effective.

5.4.2 Focus of the in-service sessions

In terms of the research findings, the in-service sessions should focus on the following actions:

- Address the pedagogical issues as revealed by the STAM, that is, the content, the teaching, assessment practices, interactions between the teacher and the students and resources availability.

- Educate teachers about the STAM framework shown in Table 5.2 and Appendix A1 to A5 category A to C also the characteristics that are relevant for each type of teaching style (See Section 5.2).

- Encourage teachers to utilise the STAM in every lesson plan, by, for example, writing their lesson plan record to include the kind of content, the teaching, the assessment practices, the interactions and resources that will be used during the lesson.

- Recommend teachers to observe each other's lessons and record actions and activities as guided by the 22 STAM descriptors. The results and suggestions for improvement can be discussed with the in-service personnel. If the teachers can use STAM as part of their daily lesson preparation and also use STAM to observe each others' lessons in pairs or groups this will ensure sustainability of implementation of the STAM and to serve the purpose of the philosophy of Outcome Based Education (OBE) that calls for lifelong learning (Department of Education, 1997a).

Teachers should be encouraged to work together in the form of cooperative learning which is in line with the National Strategy of Tirisano, a Sotho word meaning working together (Department of Education, 2001). The teachers should be encouraged to form teams of mathematics teachers in the same school to discuss mathematics topics as well as logistical issues such as year mark compilations, dispersing information from the Department of Education and learner discipline.

Teachers need to be involved in sharing their expertise teaching with each other, that is 'drawn from their own and other teachers' experiences and knowledge' (Thair & Treagust, 1997). Working together also means that teachers from different schools can start working together to discuss specific problems, exchange resources and even seek help from mathematics experts from universities, subject advisors, in-service personnel or other schools.

5.4.3 Specific issues related to STAM

The content to be dealt with during the in-service sessions will be as determined by the Department of Education for the new Further Education and Training Certificate FETC (Schools) as stipulated in the National Curriculum Statements (NCS) Grades 10-12 (Schools). Concerning professional attitudes, in-service sessions should include the discussion of South African Council of Educators (SACE) guide on teacher professional conduct.

Based on the observations and analyses of lessons presented by these eight township teachers, attention needs to be given to alternative approaches for questioning skills, how to handle homework assignments, group discussions, how to deal with chorus responses, lesson organisation and the use of instructional tools such as the textbook and teaching aids and lack of stationery. Each of these approaches could be improved by attention to basic issues. For example, in the case of chorus responses individual responses to questions posed by the teacher should be encouraged.

With group assignments, it is suggested that this be done in three ways. Firstly, learners have a group discussion about possible problem solutions and submit individual assignments. Secondly, a whole group discussion on the problem solution is conducted by the teacher and each learner writes individual assignments Thirdly, with group submissions, learners have a group discussion and one learner writes the problem solution on a script and each learner includes a description of what they did and how they contributed to the problem.

For assessment, teachers should be exposed to different ways of assessing mathematics; for example, in addition to tests and portfolios, projects, presentations, posters could be used. Frequent use of pre-testing and post-testing could be done with each topic to help identify prior learning and the depth of understanding of mathematical concepts.

For group discussions to provide solution to a problem, there is need for a whole group discussion followed by individual presentation by selected students to the whole class. When students are solving homework or class-work problems on the chalkboard they should be encouraged to say what they are doing and allow to be questioned to clarify the meaning of written and spoken statements.

Other important specific issues include the following:

- Textbook use: All learners need to be encouraged to bring their textbooks to class and in this case there will be a need to involve parents to monitor the situation.

- Portfolio assignments: These assignments should be done on an individual basis and that the level of difficulty of the problems should be the same as that of the external examination.

- Teaching aids: Both the learners and the teacher need to contribute towards collecting, designing and displaying teaching aids.

- Questioning strategies: there is a need to include thought provoking questions such as, why, how and what.

- Homework: There is a need to check whether learners have done their homework and also encourage them to do more exercises besides those given for homework.

- Teachers need to come to class with written out lesson plans and worked out problems and tentative questions. Each lesson needs to have pre-planned activities with lesson divisions within the class period.

- Concerning teacher and learner materials such as calculators, mathematical instruments or stationery, these needs to be pre-organised. For example, requisitions of teaching and learning material within the school premises or outside the school should be prior to the lesson. Furthermore, availability of teacher and learner material is an issue that will need to be discussed at staff meetings and or at parent meetings.

5.5 Limitations of the study

The limitations of the study relate to both the size of the sample of teachers observed, the choice of the diagnostic instruments, and the data collection procedures.

5.5.1 Sample size

The sample used in the study comprised eight teachers in three secondary schools in a township in South Africa. Initially, the researcher wanted to use four schools, but unfortunately one school declined to be involved. Another limitation concerned the lesson content which in some lessons could not be used for meaningful analysis using the STAM framework because little work was done during the lesson and some lessons were repeat lessons. Subsequently, 12 mathematics lessons of Grade 10-12 teachers were analysed in detail, there being eight lessons at two technical schools and four lessons at a high school. This was unavoidable, since the fourth school declined. This sample represents only a small proportion of mathematics teachers in township schools and they may not be representative of the teachers in township schools throughout South Africa. However, observations and analysis of lessons taught by this small sample was able to bring an understanding of the status of mathematics teaching in these township schools. Nevertheless, it would be surprising if the findings were not common in township schools because there are similar factors which promote or inhibit learning in township schools in South Africa (Taylor & Vinjevold, 1999).

5.5.2 Instrument

The framework of Gallagher and Parker (1995) was used to characterise the lessons into didactic, transitional and conceptual teaching. The researcher was the one interpreting the instrument, which might be biased to the researcher's conclusions. To minimize the researcher bias on the interpretations of the instrument, these were checked through discussions with the supervisor. The instrument was designed for assessing in a different country within a different context and was adapted for analysing lessons of South African mathematics teachers with its unique background of Bantu Education and multiculturalism and multilingualism. Imported instruments are often criticised for carrying with them socio-cultural factors (Aldridge, Fraser, & Huang, 1999; Brislin, 1970). However, the aspects of STAM under investigation are general for any lesson, whether international or national, and include an analysis of the content knowledge, the teachers' teaching, interactions, assessment and resources availability which are the basis of any lesson.

5.5.3 Data collection

Field notes from observations and a videotaped lesson served as the major data collection instruments for this research. The presence of the researcher and the use of the video could have impacted on the classroom environment. However, in this study, both the learners and the teachers were informed that the information was for research purpose and they seemed not to do anything unusual during the lessons (Section 3.4.3). One temporary teacher, Ms Makola, was part of the sample. Her employment status might have impacted on the way she taught mathematics, although we cannot say how this influenced the findings from the analysis of her lesson.

5.6 Implications for future research

STAM's effectiveness in this study implies that this instrument could be used in South Africa by researchers, teacher trainers and for professional development programmes. When STAM is used in pre-service and in-service education, all the five aspects of STAM, namely, content, teachers' actions, students' actions, resources and environment should be emphasised in every single lesson planning, the teaching and subsequent reflection of the lesson. For practising teachers, STAM could be a basis for lesson planning and the issues discussed in the in-service programmes could be implemented in the classroom. The STAM descriptors enable teachers to develop a sense of the target criteria for teaching that is designated as didactic, transitional and conceptual. Having identified the state of mathematics teaching in township schools, there is a need to find strategies for moving the teachers to the next level. Firstly, to move them from didactic teaching through to transitional teaching and conceptual teaching. The use of STAM could also be adapted for analysing teaching in other subjects.

This is the first research in South Africa to use the framework of Gallagher and Parker (1995) to analyse the teaching of mathematics in township schools. While the sample in this study was small, the issues that are raised form part of the teachers' daily activities. This research, however, provided some detailed insights into the learning and teaching of mathematics in township schools which are issues to which the research community in South Africa has not yet paid sufficient attention and which can be used as a basis for professional development strategies. The author intends conducting the research with a larger sample to be able to make further generalisations and also incorporate an interview schedule that includes STAM aspects and issues that were raised in the synthesis of the findings. Issues of homework, questioning strategies, textbook use and chastising learners could be followed up with interviews to provide further understanding and to help determine ways of addressing them. This approach will enable a conception of the difficulties of teaching and learning of mathematics in South African township schools.

When STAM is incorporated with in-service education, the issues from the pre-democratic period and post-apartheid period of, for example, the quality of training, the methods of training, teacher qualifications, professional and teacher knowledge and various strategies to dismantle inherited inequalities need to be taken into consideration. Future studies using STAM should incorporate South Africa's unique cultural dimension into the instrument because of the multicultural nature of the

South African education system with 11 official languages. An example worthy of investigation is gaining a better understanding of the impact of code switching on mathematics teaching in township schools.

5.7 Conclusion

This thesis represents the first study to be carried out in South Africa using STAM to investigate teaching in secondary mathematics classrooms in township schools. The instrument was able to successfully identify the classroom characteristics in terms of the content, the teaching, and assessment practices, interactions between the teachers and the students, and resources.

As shown by the results, the content, the teaching, the assessment practices, interactions and resources use and availability in the classroom are primarily of a didactic nature and teachers need assistance in making their teaching along the continuum towards conceptual teaching and later towards constructivist teaching approaches. Recent reforms in South Africa for changes in mathematics education, through the introduction of Curriculum 2005, involve transformative actions which emphasise active learning, continuous and varied assessment approaches, critical thinking, integration of knowledge, relevant and connected to real life situations, learner-centred activities and the teacher as facilitator of knowledge. However, based on the lessons observed, these teachers seem unprepared to teach the reformed curricula advocated by the government because of insufficient preparation they had in their teacher training and lack of current opportunities for in-service as discussed in Chapter 2. Moreover, the specific outcomes to be achieved in mathematics shown in Table 2.3 require a move away from didactic teaching and identify more with conceptual teaching styles. These teaching styles involve, for example, a demonstration of understanding of mathematical concepts, use of a variety of teaching strategies, integration of mathematics in various social and cultural contexts, and the use of multiple resources.

This research has identified teaching issues focussed on three township schools that reflect the historical background of these townships, the education system and the teachers' training. Consequently, it is not surprising that the results presented in

Chapter 4 are as they are and a different strategy of intervention using in-service education will need to be implemented that starts where these teachers are both conceptually and pedagogically in terms of their teaching approaches. Any intervention strategy needs to be conscious of the teachers' background with respect to schooling and teacher training under Bantu Education that has been discussed in Chapter 2. A synthesis of the results in Chapter 5, as revealed by the STAM descriptors, showed that not only is the teaching style in township schools primarily didactic but also that there are a preponderance of several issues that limit effective learning such as unproductive questioning, chorus responses, poor classroom discipline, teacher talking the whole lesson, inappropriate ways of chastising learners and unprofessional attitudes that surfaced during the analysis which are specific to these three schools.

5.8 Summary of the thesis

This study investigated the teaching of mathematics in township secondary schools. Initially, the background to the education system in South Africa in the pre-democratic period (before 1994) and post-democratic period (after 1994) was discussed in Chapter 2 to form a base for understanding the quality of education and the training of mathematics teachers. Chapter 3 outlined the research processes followed to investigate the teaching of mathematics in township schools and introduced the schools, teachers, their students and the instrument to analyse the lessons. In Chapter 4, STAM was used to characterise the teaching into didactic, transitional and conceptual approaches using the 22 STAM descriptors, which determined the content, teachers' actions and assessment, students' actions, resources and environment (Gallagher & Parker, 1995). Chapter 5 contained a synthesis of the results as revealed by the analysis in Chapter 4 using the adapted framework of Gallagher and Parker (1995) in response to the research problem that gave rise to the study. The chapter concluded with limitations of the study and recommendations for improving mathematics teaching in township schools.

REFERENCES

Adams, P. E., & Krockover, G. H. (1997). Beginning science teacher cognition and its origins in the Pre-service secondary Science teacher program. *Journal of Research in Science Teaching, 34*(6), 633-653.

Adams, P. E., & Krockover, G. H. (1999). Stimulating constructivist teaching styles through use of an observation rubric. *Journal of Research in Science Teaching, 36*(8), 955-971.

Adams, P. E., & Tillotson, J. (1995). Why research in the service of science teacher education is needed. *Journal of Research in Science Teaching, 32*, 441-443.

Adler, J. (1995). *Looking back, inside and ahead: An evaluation of Mathematics education project 1993-1995.* Johannesburg: University of the Witwatersrand.

Adler, J. (1998). A language of teaching dilemmas: Unlocking the complex multilingual secondary mathematics classroom. *For the Learning of Mathematics, 18*, 24-33.

Adler, J. (2001). *Teaching mathematics in multilingual classrooms.* The Netherlands: Kluwer Academic Publishers.

Aldridge, J. M., Fraser, B. J., & Huang, T.-C., I. (1999). Investigating classroom environments in Taiwan and Australia with multiple research methods. *The Journal of Educational Research, 93*(1), 48-62.

Aldridge, J. M., Taylor, P. C., & Fraser, B. J. (2000). Constructivist learning environments in a cross-national study in Taiwan and Australia. *International Journal of Science Education, 22*(37-55).

Armour -Thomas, E., Clay, C., Domanico, R., Bruno, K., & Allen, B. (1998). *An outlier study of elementary and middle schools in New York city: Final report* (New York City Board of Education). New York.

Arnold, M. (1981). Steve Biko: Black consciousness in South Africa. *Harvard Educational Review, 51*(1), 200-201.

Arnott, A., & Kubeka, Z. (1997). *Mathematics and science teachers: Demand, utilisation, supply and training in South Africa.* Johannesburg: EduSource 97/01.

Austin, P., Forster, L., Mgobozi, N., England, V., Lynch, P., Webb, P., Potgiter, D., & Linneman, S. (2002). *Evaluating South African curriculum interventions: Exploring the reasoning skills, classroom climate and discourse strategies as a triangulation.* Paper presented at the The South African Association for Research in Mathematics, Science and Technology Education.

Bailey, C. A. (1996). *A guide to field research.* London: Pine Forge Press.

Baine, D., & Mwamwenda, T. (1994). Education in Southern Africa: Current conditions and future directions. *International Review of Education, 40*(2), 115-136.

Baird, J. R., & White, R. T. (1996). *Metacognitive strategies in the classroom.* London: Teachers college Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W.H. Freeman.

Bansilal, S. (2002). *An investigation into teachers knowledge in algebra.* Paper presented at the South African Association for Research in Mathematics, Science and Technology Education, Durban.

Battersby, J. (1994). Apartheid's homelands haunt election campaign. *The Christian Science Monitor, 86*(78), 6.

Behr, A. L. (1978). *New perspectives in South African education.* Durban: Butterworths.

Bogdan, R., & Biklen, S. (1992). *Qualitative research for education.* Boston, MA: Allyn and Bacon.

Booth, L. R. (1995). Learning and teaching Algebra. In L. E. Grimson (Ed.), *Teaching secondary mathematics* (pp. 104 -119). London: Sage Publishers.

Brislin, R. (1970). Back translation for cross-cultural research. *Journal of Cross-Cultural Psychology, 1*, 185-216.

Bruer, J. T. (1993). *Schools for thought: A science of learning in the classroom.* Massachusetts London: The MIT Press Cambridge.

Carlsen, W. (1993). Teacher knowledge and discourse control: quantitative evidence from novice biology teachers' classrooms. *Journal of Research in Science Teaching, 30*(5), 471-481.

Chi, M., Glaser, R., & Rees, E. (1982). Expertise in problem solving. *Advances in Psychology of Human Intelligence, 1*(7).

Chisolm, L., Volmink, J., Ndhlovu, J., Potenza, E., Mohamed, H., Muller, J., Lubisi, C., Vinjevold, P., Ngozi, L., Malan, B., & Mphahlele, L. (2000). *A South African curriculum for the Twenty First Century. Report for the Review Committee on Curriculum 2005*. Pretoria.

Christie, P. (1985). *The right to learn : The struggle for education in South Africa.* Johannesburg: Ravan Press.

Clark, J. (1999). *Challenges to practice, constraints to change- exploring school-based factors inhibiting a science teacher's implementation of curriculum innovation.* Paper presented at the South African Association for Research in Mathematics, Science and Technology Education, Harare.

Cochran, K. F., De Rutter, J. A., & King, R. A. (1993). Pedagogical content knowing- an integrative model for teacher preparation. *Journal of Teacher Education, 44*, 263-272.

Cohen, L., & Manion, L. (1997). *Research methods in education.* London: RoutledgeFalmer.

Cohen, L., Manion, L., & Morris, K. (2000). *Research methods in education.* London: RoutledgeFalmer.

Coladarci, T., & Breton, W. (1997). Teacher efficacy, supervision, and the special education resource-room teacher. *Journal of Educational Research, 90*(4), 230-239.

Creswell, J. W. (1994). *Research design: Qualitative and quantitative approaches.* London: Sage Publications.

Cuthbertson, G. (1998). *From white supremacy to black liberation: Intellectual lineages from South Africa in the making of America.* Pretoria: University of South Africa.

Darling-Hammond, L. (1998). Teachers and teaching: Testing policy hypothesis from the National Commission Report. *Educational Researcher, 27*, 514.

Denzin, N. K., & Lincoln, Y. S. (1994). Entering the field of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research.* Thousand oaks, CA: Sage.

Department of Education. (1995). *South African Qualifications Authority* (No. 897). Pretoria: Department of Education.

Department of Education. (1996a). *National Education Policy Act (NEPA)* (Act No.27). Pretoria: Department of Education.

Department of Education. (1996b). *South African Constitution*. Pretoria: Department of Education.

Department of Education. (1996c). *South African Schools Act* (Act No. 84). Pretoria: Department of Education.

Department of Education. (1997a). *Curriculum 2005: Lifelong learning for the 21st Century* (National Department of Education). Pretoria: Department of Education.

Department of Education. (1997b). *Language -in-Education Policy*. Pretoria: Department of Education.

Department of Education. (1999). *The presidential educative initiative research report*. Pretoria: Department of Education.

Department of Education. (2000a). *Draft intervention national strategy for science, mathematics and technology education*. Pretoria.

Department of Education. (2000b). *Norms and Standards for Educators, Government Gazette* (20844). Pretoria: Department of Education.

Department of Education. (2001). *National Strategy for mathematics, science and technology education in General and Further Education and Training*. Pretoria.

Department of Education. (2003). *Tshwane South; Intervention programmes: Mathematics*. Pretoria: Department of Education.

Donald, D. (1995). High school underachievement as a legacy of Apartheid: Implications for the development of an appropriate education support service in South Africa. *IASE Monograph. Empowering children with special needs: Practices around the world*, 137-142.

Donald, D. R., & Hlongwane, M. M. (1989). Consultative psychological service delivery in context of black education in South Africa. *International Journal of Special Education, 4*(2), 119-140.

Emmer, E., & Hickman, J. (1990). *Teacher decision making as a function of efficacy, attribution, and reasoned action*. Paper presented at the American Educational Research Association, Boston.

Enoch, L., & Riggs, I. (1990). Further development of an elementary science teaching efficacy belief instrument: A pre-service elementary scale. *School Science and Mathematics, 90* 694-706.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 119 -160). New York, N.Y: Macmillan.

Erickson, T. L., & Barr, L. (1985). Alternative credentialing: Lessons from vocational education. *Journal of Teacher Education, 36*(3), 1619.

Essop, A. (2000). *Press release for norms and standards for educators*. Retrieved, from the World Wide Web: http://eduaction.pwv.gov.za/Media/Statements_2000/Feb2000/Norsm_Standards.htm [17 March 2003]

Ferguson , R. (1991). Paying for public education: New evidence on how and why money matters. *Harvard Journal of Legislation, 28*(2), 465-498.

Ferguson, R. F., & Ladd, H. E. (1996). How and why money matters: An analysis of Alabama schools. In H. E. Ladd (Ed.), *Holding schools accountable* (pp. 265-298). Washington, DC: Brookings Institution.

Fraser, B. J., & Tobin, K. (1990). *Environments for learning science and Mathematics. Monograph.* Perth: Curtin University of Technology.

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction* (6th ed.). New York: Longman Publishers.

Gallagher, J. J. (1991). *Interpretive research in science education* (Monograph 4): NARST.

Gallagher, J. J., & Parker, J. (1995). *Secondary teacher analysis matrix.* East Lansing, MI: Department of Teacher Education, Michigan State University.

Glaser, R., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Chicago: Aldine.

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction.* Melbourne: Longman Cheshire.

Glover, H., & King, L. (2000). *An analysis of the Algebraic misconceptions held by a group of Eastern Cape intermediate phase teacher.* Paper presented at the Southern African Association for Research in Mathematics and Science Education, Port Elizabeth.

Goldhaber, D. D., & Brewer, D. J. (1998). When should we reward degree teachers? *Phi Delta Kappan, 80*(2), 134-138.

Graven, M. H. (1997). *Researching the working of in-service workshops with teachers* (A research report.). Johannesburg: The RADMASTE Center, University of the Witwatersrand.

Graven, M. H. (1998). *The effectiveness of In service workshops with mathematics teachers and students.* Johannesburg: The RADMASTE Center, University of the Witwatersrand.

Graven, M. H. (2002). *Mathematics teacher learning, communities of practice, and the centrality of confidence.* Unpublished PhD thesis, University of the Witwatersrand, Johannesburg.

Gray, B. (1995). Future directions in science teacher education. *South African Journal of Higher Education, 9*(1), 47-52.

Grayson, D. J. (2003). *Launch of the centre: Speech given by Professor Diane Grayson.* Pretoria: University of South Africa.

Grayson, D. J., & Ngoepe, M. (2003). *A survey of South African mathematics and science teachers' professional actions and attitudes.* Paper presented at the Southern African Association for Research in Mathematics, Science and Technology Education, Waterford Kamhlaba, Swaziland.

Grayson, D. J., Ono, Y., Ngoepe, M. G., & Masakazu, K. (2001). *A comparison of mathematics and science high school teachers' attitudes in Japan and South Africa.* Paper presented at the Southern African Association for Research in Mathematics Science and Technology Education, Maputo.

Guba, E. A., & Lincoln, Y. S. (1989). *Fourth generation evaluation.* London: Sage Publications.

Guba, E. G. (1990). The alternative paradigm dialog. In E. G. Guba (Ed.), *The paradigm dialog* (pp. 17-30). Newbury Park, CA: Sage.

Haberman, M. (1991). The pedagogy of poverty versus good teaching. *Phi Delta Kappan, 73*, 290-294.

Hiebert, J., Gallimore, R., Garnier, H., K.B., G., Hollongsworth, H., Jacobs, J., Miu-Ying Chui, A., Wearne, D., Smith, M., Kersting, N., Manaster, A., Tseng, E., Etterbeek, W., Manaster, C., Gonzales, P., & Stigler, J. (2003). *Teaching Mathematics in seven countries results from the TIMSS 1999 video study* (U.S Department of Education).

Hobden, P. (2002). *Reclaiming the meaning of problem solving: The need for a common understanding of the terms problem and problem solving.* Paper presented at the Southern African Association for Research in Mathematics, Science and Technology Education, Durban.

Howie, S. J. (1997). *Mathematics and science performance in the middle school years in South Africa: A summary report on the performance of the South African pupils in the third international mathematics and science study.* Pretoria: Human Sciences Research Council.

Howie, S. J. (2001). *Mathematics and science performance in Grade 8 in South Africa 1998/1999. TIMMS-R South Africa.* Pretoria: Human Sciences Research Council.

Howie, S. J., & Plomp, T. (2002). *School and classroom level factors and pupils' achievement in mathematics in South Africa: a closer look at the South African TIMSS-R data.* Paper presented at the South African Association for Research in Mathematics, Science and Technology Education, Durban.

Human Sciences Research Council (HSRC). (1981). *Report of the work committee of the HSRC investigating into education.* Pretoria: Human Sciences Research Council.

Idiris, S., & Fraser, B. J. (1997). *Teacher supply, teacher quality, and teacher turnover* (U.S. Department of Education). Washington D.C.: National centre for education statistics.

Jita, L. (2002). *A Transformative practice in science education: What is it? What does it look like? Images form South African classrooms.* Paper presented at the Southern African Association for Research in Mathematics, Science and Technology Education, Durban.

Johnson, S., Scholtz, Z., Hodges, M., & Botha, T. (2002). *A study of the use of curriculum materials introduced to science teachers in the Western Cape.* Paper presented at the Southern African Association for Research in Mathematics, Science and Technology Education, Durban.

Joubert, P. (1992). *The In-Service training of beginner lecturers at technical colleges with reference to the teaching of Mathematics.* Unpublished Master of Education dissertation, Rand Afrikaans University, Aukland Park.

Kachelholffer, P. M. (1995). Teacher Enrichment Programs in Kwandebele, South Africa. *Higher Education Policy, 8*(2), 72-78.

Kahn, M. (2000). *Toward a strategy for the development of science, mathematics and technology education.* (Working document). Pretoria: National Department of Education.

Kandjeo-Marenga, H. U., Kapenda, H. M., Gaseb, N., Kasanda, C. D., Lubben, F., & Campbell, B. (2003). *Teachers questioning in mathematics and science classrooms in Namibia.* Paper presented at the Southern African Association for Research in Mathematics Science and Technology Education, Waterford Kamhlaba Swaziland.

Kieran, C. (1992). The learning and teaching of school Algebra. In D. A. E. Grouw (Ed.), *Handbook of research on mathematics, teaching and learning* (pp. 390-419).

Killion, J. (1998). *Learning depends on teacher knowledge.* Retrieved, from the World Wide Web: http://www.nsdc.org/library/results/res12-98killion.html. December 1998 [26 September 2002].

Kim, H. B., Fisher, D. L., & Fraser, B. J. (1999). Assessment and investigation of constructivist science learning environments in Korea. *Research in Science and Technology Education, 17*, 239-249.

King , L. C. C. (2002). *Assessing the effect of an instructional intervention on the geometric understanding of learners in a South African primary school.* Paper presented at the Southern African Association for Research in Mathematics Science and Technology Education, Durban.

Koballa, T., & Tippins, D. (2000). *Cases in middle and secondary science education: The promises and dilemmas.* Upper Saddle River, N.J: Merill Prentice Hall.

Koul, R., & Rubba, P. (1999). An analysis of the reliability and validity of personal internet teaching efficacy beliefs scale. *Electronic Journal of Science Education, 4*(1), 1-9.

Lauer, J. M., & Asher, J. W. (1988). *Composition research: Empirical designs.* New York: Oxford University Press.

Lawson, A. E. (1995). *Science teaching and the development of thinking*. Belmont, CA: Wadsworth Publishing.

Lesage, J. M. (1994). South Africa: Bridging the Gap. *New African, 321*, 20-21.

Lincoln, Y. S., & Guba, E. A. (1985). *Naturalistic inquiry.* Beverley Hills, CA: Sage.

Lofland, J. (1971). *Analyzing social settings.* Belmont, CA: Wardsworth.

Lord, T., Travis, H., Magill, B., & King, L. (2000). *Comparing student-centered and teacher-centered Instruction in College Biology Labs* (Department of Biology). Indiana: Indiana University of Pennsylvania.

Macdonald, M. A., & Rogan, J. M. (1988). Innovation in South African Science education (Part 1), science teaching observed. *Science Education, 72*(2), 225-236).

Maclsaac, D., & Falconer, K. (2002). Reforming physics education via RTOP. *The Physics Teacher, 40*(8), 479-485. Available from http://ojps.aip.org/tpt/> [9 April 2003].

Maclsaac, D., Sawada, D., & Falconer, K. (2001). *Using the Reformed teaching Observation Protocol (RTOP) as a catalyst for self-reflective change in secondary science teaching.* Paper presented at the American Educational Research Association, Seattle.

Magill, B. (2001). *Reconstructing a secondary science teacher analysis matrix into a "User Friendly" Likert Scale Assessment Tool.* Unpublished Masters dissertation, Indiana University of Pennsylvania, Indiana.

Malcolm, C. (2001). *Schools that succeeds against the odds.* Paper presented at the Southern African Association for Research in Mathematics, Science and Technology Education, Maputo.

Mamiala, L. T. (2002). *Teachers' and textbooks' use of explanations in school chemistry and students' perceptions of these explanations.* Unpublished Doctor of Science Education, Curtin University of Technology, Perth.

Martin, J. R. (1970). *Explaining, understanding, and teaching.* New York: Mc Graw-Hill.

McMillan, J. M. (1996). *Educational research: Fundamentals for the consumer.* New York: Harper Collins Publishers Inc.

Merriam, S. B. (1988). *Case study research in education: A qualitative approach.* London: Jossey-Bass Publishers.

Merriam, S. B. (1998). *Qualitative research and case study applications in education.* San Francisco: Jossey- Bass Publishers.

Miles, M. B., & Huberman, A. M. (1994). *An expanded source book: Qualitative data analysis* (2nd ed.). Thousands Oaks, CA: Sage.

Mji, A. (1998). Prospective teachers' conceptions about, and approaches to mathematics. *Journal for the Southern African Association for Research in Mathematics and Science Education,* 2(1), 72-76.

Moore, W., & Esselman, M. (1992). *Teacher efficacy, power, school climate and achievement: A desegregating district's experience.* Paper presented at the American Educational Research Association, San Francisco.

Mosimege, M. (2000). *An analytical framework for classroom video recordings for cultural specific mathematical activities.* Paper presented at the Southern African Association for Research in Mathematics and Science Education, Port Elizabeth.

Mtetwa, D. K. J., Ncube, K., Ndeya - Ndereya, C. N., & Engels, E. (1998). Teaching and educational research methods course to in-service science and mathematics teachers through authentic field experiences: A case study at the University of Zimbabwe. *Journal of the Southern African Association for Research in Mathematics and Science Education,* 2(1), 13-20.

Nagao, M., Hattori, K., Kita, M., & Ono, Y. (1999). *Project concept paper for Mpumalanga secondary science initiative.* Pretoria: Prepared for JICA.

National Department of Education. (1997). *Senior phase policy document.* Pretoria: Department of Education.

Ncedo, N., Peires, M., & Morar, T. (2002). *Code switching revisited: The use of language in primary school science and mathematics classrooms.* Paper presented at the South African Association for Research in Mathematics, Science and Technology Education, Durban.

Nduna-Watson, N. (1994). *Contextual factors and constraints that influence Black teachers in South Africa when implementing curriculum: A case of geography teachers.* Unpublished PhD, Michigan State University, East Lansing.

Ngoepe, M. G. (1998a). *An investigation into the attitudes of student teachers at one college of education in the Northern province (Former Lebowa homeland) to mathematics learning and teaching.* Paper presented at the Southern African Association for Research in Mathematics and Science Education, Pretoria.

Ngoepe, M. G. (1998b). *An investigation into the attitudes of student teachers in the former Lebowa Homeland in South Africa to mathematics learning and teaching.* Unpublished MEd, University of Birmingham, Birmingham.

Ngoepe, M. G. (2002). *Explanations by mathematics teachers: An Analysis.* Paper presented at the International Psychology of Mathematics Education, Norwich.

Ngoepe, M. G., & Grayson, D. J. (2000). *How teachers prepare students for matric examination: Interviews with mathematics teachers.* Paper presented at the Southern African Association for Research in Mathematics and Science Education, Port Elizabeth.

Ngoepe, M. G., Grayson, D. J., & Treagust, D. F. (2001). *Towards establishing a baseline information for the professional development of secondary mathematics teachers in South Africa.* Paper presented at the Australian Association for Research in Education, Fremantle.

Nkabinde, Z. P. (1997). *An analysis of educational challenges in the New South Africa.* Oxford: University Press.

Nkopodi, N. (2001). *Science teaching in a disadvantaged school: A case study.* Paper presented at the Southern African Association for the Research in Mathematics, Science and Technology Education, Maputo.

Nxumalo, O. E. H. M. (1990). Teacher education and social change. *Painadonomia, 16*(2), 27-38.

Oliver, J., & Glencross, M. J. (1995). An evaluation of teaching techniques used in Transkei, South Africa to assess competency in primary mathematics. *Psychological Reports, 76*, 747-754.

Ottervanger, W. (2002). *Teacher support materials as a catalyst for science curriculum implementation in Namibia.* Paper presented at the South African Association for Research in Mathematics, Science and Technology Education, Durban.

Parsons, N. (1982). *A new history of South Africa.* London: Macmillan Education Ltd.

Patton, M. Q. (1990). *Qualitative evaluation and research methods.* London: Sage Publication.

Perso, T. F. (1993). *Overcoming misconceptions in algebra* (The Mathematical Association of Western Australia (Inc.)). Perth.

Piburn, M., Sawada, D., Falconer, K., Turtley, J., Benford, R., & Bloom, L. (2000). *Reformed Teaching Observation Protocol (RTOP).* Retrieved, from the

World Wide Web: http:/Purcell.phy.nau.edu/AZTEC/rtop/RTOP_full/PDF/ [9 April 2003].

Pinto, D. (2001). *Directory of the science, engineering and technology foundation programmes and proceedings of the 'Indaba' of the Science, Engineering and Technology Foundation Programmes.* Johannesburg: University of the Witwatersrand College of Science.

Polya, G. (1973). *How to solve it.* New Jersey: Princeton University Press.

Prawat, R. S. (1989). Teaching for understanding: Three key attributes. *Teaching and Teacher Education, 5*(4), 315-328.

Priestly, H., Priestly Sutman, W. J., Schmuckler, J. S., Hilosky, A., & White, M. (1998). *Evaluating the use of the inquiry matrix.* Paper presented at the National Association for Research in Science Teaching, San Diego, CA.

Raudenbush, S., Rowen, B., & Cheong, Y. (1992). Contextual effects on the self-perceived efficacy of high school teachers. *Sociology of Education, 65*(2), 150-167.

Rogan , J. M., Grayson, D. J., van den Akker, J., Ndlalane, T., & Aldous, C. (2002). *The implementation of Curriculum 2005 in Mpumalanga: Towards a theory of implementation.* Paper presented at the Southern African Association for Research in Mathematics, Science and Technology Education., Durban.

Rollnick, M., & Kahn, M. (1991). *Science education in nearly new South Africa.* Paper presented at the Physical Science proceedings of 14th National Convention on Mathematics and Natural Science Education, Capetown.

Rubeck, M. L., & Enoch, L. G. (1991). *A path analytic model of variables that influence science and chemistry teaching self-efficacy and outcome expectancy in the middle school science teachers.* Paper presented at the National Association for Research in Science Teaching, Lake Geneva, WI.

Ryan, G. W., & Bernard, H. R. (2000). Data management and analysis methods. In D. N.K. & L. (Eds.) (Eds.), *Handbook for qualitative research* (2nd ed., pp. 769-802). Thousand Oaks: Sage Publications.

Sawada, D., Piburn, M., Turley, J., Falconer, K., Benford, R., Bloom, I., & Judson, E. (2000). *Reformed Teaching Observation Protocol (RTOP) Training Guide.* ACEPT Technical Report No. IN00-2). Tempe, AZ: Arizona Collaborative for Excellence in the Preparation of Teachers. Retrieved, from the World Wide Web: http:/Purcell.phy.nau.edu/AZTEC/rtop/RTOP_full/PDF/ [9 April 2003].

Scriven, M. (1988). Explanations, predictions and laws. In J.C. Pitt (Ed.), *Theories of explanation* (pp. 51-74). New York: Oxford University press.

Setati, M. (1998). *Languages practices in mathematics classrooms: Focus on code switching, chanting and chorusing.* Paper presented at the Southern African Association for Research in Mathematics and Science Education, Pretoria.

Shanker, A. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching, 36*(8), 930-954.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations for the new reform. *Harvard Educational Review, 57*, 1-22.

Simmons, P. E, Emory, A., Carter, T., Coker, T., & Finnegan, B. et al. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching, 36*(8), 930-954.

Simon, A. (1991). Reasons provided by black pupils in the rural Mahlabatini area in Natal province, South Africa, for poor academic preformance in black secondary schools. *Journal of Negro Education, 60*(4), 581-592.

Slammert, L. (1991). Rethinking mathematical knowledge: The quest for people' s Mathematics in South Africa. In J. D. Jansen (Ed.), *Knowledge and power in South Africa: Critical perspectives across the disciplines.* Johannesburg: Skottaville.

Slavin, R. E. (1996). *Educational Psychology.* Englewood Cliffs, NJ: Prentice Hall.

Soeharto, S. (1998). *The effects of constructivist learning environment on grade six student achievement and attitude toward mathematics in Indonesian primary schools.* Unpublished PhD thesis, University of Houston.

Spradley, J. M. (1980). *Participant observation.* New York: Holt, Rinehart and Winston.

Stigler, J. W. J., Gonzales, P., Kawanaka, T., Knoll, S., & Serrano. (1999). *The TIMMS videotape classroom study: Methods and findings from an Exploratory Research Project on Eighth - Grade Math Instruction in Germany, Japan, and The United States.* (U.S. Department of Education). Washington DC: National Centre for Education Statistics.

Stols, G. (2003). *The correlation between teachers and their learners' mathematical knowledge in rural schools.* Paper presented at the Southern African Association for the Research in Mathematics, Science and Technology Education, Waterford Kamhlaba.

Strauss, A. L., & Corbin, J. (1994). *Grounded theory methodology: An overview.* Thousand Oaks, CA: Sage Publications.

Taole, K. (2000). *Calling for a shift in the existing research culture.* Paper presented at the Southern African Association for Research in Mathematics and Science Education, Port Elizabeth.

Taylor, N., & Vinjevold, P. (1999). *Getting learning right- report of the President's Education initiative research report.* Johannesburg: The Joint Education Trust.

Taylor, P. C. (1991). *Development of an instrument for assessing constructivist-learning environments.* Paper presented at the American Educational Research Association, New Orleans.

Taylor, P. C., Dawson, V., & Fraser, B. J. (1995). *Classroom learning environments under transformation: A constructivist perspective.* Paper presented at the American Educational Research Association, San Francisco.

Taylor, P. C., Fisher, N. J., & Fraser, D. L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research, 27*, 293-302.

Tesch, R. (1990). *Qualitative research analysis types and software tools.* New York: The Falmer Press.

Thair, M., & Treagust, D. F. (1997). A review of teacher development reforms in Indonesia secondary science: The effectiveness of practical work in Biology. *Research in Science Education, 27*(4), 581- 597.

Treagust, D., & Harrison, A. G. (2000). In search for explanatory frameworks: An analysis of Richard Feyman's lecture' Atoms in motion'. *International Journal of Science Education, 22*(11), 1157-1170.

Treagust, D. F., Duit, R., & Fraser, B. F. (1996). *Improving teaching and learning in science mathematics*. New York: Teachers College Press.

Tschannen-Moran, M., Woolfolk - Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*, 202-248.

Vithal, R. (1998). *Disruptions and data: The politics of doing mathematics research in South Africa.* Paper presented at the Southern African Association for Research in Mathematics and Science Education, Pretoria.

Walker, M. (1992). Transforming teaching in primary education: A project for development and democracy. In E. Unterhalter & H. Wolpe & T. Botha (Eds.), *Education in a future South Africa*. New Jersey: Africa World Press.

Webb, P. (1998). *Rippling Science and mathematics through township schools.* Paper presented at the Southern African Association for Research in Mathematics and Science Education, Pretoria.

Yin, R. K. (1994). *Case study techniques: Design and methods* (2nd ed.). Newbury Park, CA: Sage.

Zevenbergen, R. (1998). Ethnography in the classroom. In J. A. Malone & B. Atweh & J. R. Northfield (Eds.), *Research and supervision in Mathematics and Science Education*. London: Lawrence Erlbaum Associates.

Zuzovsky, R., & Tamir, P. (1999). Growth patterns in students' ability to supply scientific explanations: Findings from the Third International Mathematics and Science study in Israel. *International Journal of Science Education, 21*(10), 1101-1121.

APPENDIX A1

The content in the six teaching styles (A-F) as identified by Gallagher and Parker (1995)

	A Didactic	B Transitional	C Conceptual	D Early Constructivist	E Experienced Constr.	F Constructivist Inquiry
1.Structure of content	• Factual content, *factoids*	• Content tends to be *descriptive* with concepts and factoids given equal emphasis	• Content tends to be *explanatory* with conceptual content organized around key ideas	• Teacher and students negotiate understanding of *key ideas* with teacher's content emphasized	• Teacher and students negotiate understanding of *key ideas* based in students' ideas & content	• *Investigations* dominate content. Conceptual content and connections embedded into design, implementation, analysis, and report of investigation
2.Use of examples	• No examples or interconnections to: a) real world events b) related ideas c) key ideas of the subject	• Real world examples and/or related ideas separate from other pieces of content	• Examples and connections made by teacher to: a) real world events b) related ideas c) key ideas of the subject	• Teacher leads students in using examples and constructing connections to: a) real world events b) related ideas c) key ideas of concept	• Connections constructed by students with teacher's guidance to: a) real world b) related ideas c) key ideas of concept	• Connections constructed by students are related to investigation, data analysis, and concept building
3. Limits exceptions, and multiple interpretations	• Over simplified so that the limits or exceptions within content are not presented. Many statements are absolutes without qualifiers.	• Some limits, exceptions, and alternate interpretations included, but are not integrated with other content.	• Limits, exceptions, and alternate interpretations are presented as part of the content	• Teacher leads students to identify limits and exceptions that may generate alternate ways of representing or interpreting observations and events	• Teacher and students identify limits and exceptions that may generate alternate ways of representing or interpreting observations and events	• Teacher and students identify limits, exceptions, and alternate interpretations by applying knowledge to part of problem solving
4. process and history of maths	• No explicit mention of how we know. Scientific method is presented separately as rote procedure	• No explicit mention of how we know. Processes of science (observation, inference, experiment, etc.) are not integrated with content	• "How we know" included in content. Teacher integrates processes of science with concepts.	• Teacher leads students to reconstruct how evidence has been used to formulate scientific ideas and to use scientific processes to formulate and evaluate ideas	• Students, with teacher's guidance, reconstruct how evidence has been used to formulate scientific ideas and to use scientific processes to formulate and evaluate ideas	• Processes of science applied to design of project investigation, data collection, data analysis, and concept building

APPENDIX A2

Teachers' actions and assessment in the six teaching styles (A-F) as identified by Gallagher and Parker (1995)

	A Didactic	B Transitional	C Conceptual	D Early Constructivist	E Experienced Constr.	F Constructivist Inquiry
5. Teaching methods	• 1 or 2 teaching teacher-centered methods predominate	• 3 or 4 teacher-centered teaching methods, including some hands-on	• Rich repertoire of teacher-centered teaching methods, including hands-on	• Some use of student-centered methods such as group work, student writing, discussion, and concept mapping.	• Extensive use of student-centered methods	• Project method with teacher and students selecting methods of inquiry and analysis, guided by questions being investigated
6. Labs, demonstrations, and hands on activities	• Demonstrations, labs, and hands-on activities are rare	• Some demonstrations, labs, or hands-on activities which are either overly directed (cookbook) or undirected (e.g. exploration without follow up)	• Many demonstrations, labs, or hands-on activities that are conceptually focused. "Answers" generally known ahead of time	• Investigations, demon-strations, and hands-on activities lead by teacher and incorporate some students' ideas	• Investigations, demon-strations, and hands-on activities are constructed by teacher and students and build on students' ideas	• Demonstrations and hands-on activities are part of longer term investigations. Students have a high degree of input in generating question and planning investigation
7. Teacher student interactions	• Little teacher-student interaction about subject matter (chalk and talk)	• Teacher-student interaction about correctness of students' ideas about unconnected facts	• Teacher-student interaction about correct-ness of students' knowledge of conceptual content	• Teacher-student interaction about clarification and usefulness of students' ideas and understanding is teacher-directed	• Students & teacher have input into the clarification and usefulness of students' ideas and understandings	• Teacher- student interaction focused on investigations with topics and goals of inquiries often determined by students.
8. Teacher questions	• Teacher's questions call for factual recall	• Teacher's questions directed towards scientific ideas, not towards connections or applications They do not build on students' responses.	• Teacher's questions are directed towards knowledge of scientific concepts and their connections and applications. They do not build on students' responses.	• Teacher's questions are goal-oriented and occasionally emerge from students' responses. They are used to clarify students' ideas.	• Teacher's questions are goal-oriented and frequently emerge from students' responses. They are used to clarify students' ideas.	• Teacher's questions are goal-oriented, emerge from student's responses, and are used to guide investigations
9. Kinds of assessment employed	• Tests and quizzes only	• Occasional checking, in addition to tests & quizzes, of students' knowledge	• Frequent checking, in addition to tests & quizzes, of students' knowledge	• Multiple forms. Some assess students' knowledge. Some assess students' understanding.	• Multiple forms. Most assess students' understanding.	• Multiple forms arising from investigations and presentations.
10. Uses of assessment beyond grading	• None	• Checking students' knowledge	• Checking students' knowledge and preplanning	• To guide teacher in adjusting activities.	• To guide teacher and students in adjusting and carrying out activities	• To guide teacher and students in making adjustments in investigations and analysis
11. Teachers responses to student ideas	• Teacher disregards students ideas about subject matter	• Teacher may accept all students' ideas. Teacher views students' unscientific ideas as oddities.	• Teacher investigates students' ideas about subject matter and works to alter "unscientific" ideas	• Teacher occasionally seeks students' ideas and considers them in instructional decision making this information some of the time in designing activities	• Teacher actively seeks student's ideas. Assess-ment drives instructional decision making.	• Treats students as self-directed learners and interacts as co-investigator

APPENDIX A3

Students' actions in the six teaching styles (A-F) as identified by Gallagher and Parker (1995)

	A Didactic	B Transitional	C Conceptual	D Early Constructivist	E Experienced Constr.	F Constructivist Inquiry
12. Writing and other representations of ideas	• Writing and other representations of ideas not used. Short answers predominate	• Writing and other representations of ideas rarely used. Most are reconfigurations of information provided.	• Several forms of writing and other representation of ideas are used. Most are reconfigurations of information provided.	• Students occasionally use writing and other representations of ideas as part of developing their understanding and constructing meaning. Much is reconfiguring information provided.	• Students frequently use writing and other representations of ideas as part of developing their understanding and constructing meaning	• Students choose from a variety of forms of writing and other representations of ideas as part of developing their understanding and constructing meaning
13. Student questions	• Few student questions	• Student questions clarifying procedures dominate. Some questions ask for clarification of terminology or repeat of information	• Student questions focus on clarification of meaning related to specific concepts or procedure	• Some student questions focus on clarification of meaning related to specific concepts. Some address key ideas, their connections and applications. Few are procedural.	• Student questions address key ideas, their connections and applications	• Student questions address key ideas, their connections and applications in the context of a long-range, investigative framework
14. Student-student interaction	• Student-student interaction is rare.	• Some student-student interaction, mostly about procedure	• Some student-student interaction about procedure. Some about articulating scientific ideas correctly	• Some student-student interaction directed toward understanding and applying scientific ideas. Some about procedure	• Student-student interaction directed toward understanding and applying scientific ideas. Students are self-reliant	• Student-student interaction is frequent and is directed toward understanding and planning. Students are very self-reliant
15 Student-initiated	• Students rarely volunteer examples or analysis	• Students volunteer a few examples, but connections to class activities may be weak	• Students volunteer some examples related to class activities	• Students volunteer analysis as well as examples. Some are related to class activities. Others are weakly related.	• Students volunteer analysis as well as examples. Most are pertinent to class activities	• Students volunteer analysis and examples that are used in setting the direction of the class
16. Student understanding of teacher expectations	• Students are passive or ignore teacher's procedures	• Students show confusion over procedures	• Students accept procedures and role	• Students demonstrate some frustrations with role. For example, "Why doesn't the teacher just tell me the answer?"	• Students do some negotiating with teacher of procedures and role	• Students help define their role in the investigation

APPENDIX A4

Resources in the six teaching styles (A-F) as described by Gallagher and Parker (1995)

	A Didactic	B Transitional	C Conceptual	D Early Constructivist	E Experienced Constr.
17. Richness of resources	• Teacher-dominated	• Teacher-controlled. Little sharing of decision making with students.	• Teacher-controlled. Some sharing of decision making with students about use of time.	• Students & teacher make some joint decisions about time and activities	• Students & teacher make many joint decisions about time and activities
18. Uses of resources	• Few teaching aids displayed. May not be integrated with content	• Some teaching aids displayed. May not be related to content	• Many teaching aids displayed related to content	• Many teaching aids displayed related to content	• Many teaching aids displayed related to content. Some are made by students
19. Access to resources	• Few examples of students' work displayed	• Students' work displayed is typically similar for all students (i.e. worksheets or identical models)	• Some variation in students' work displayed	• Students' work displayed, includes some student creations (i.e. original posters, stories, or demos)	• Students' work displayed, includes many student creations (i.e. original posters, stories, or demos)

APPENDIX A5

Environment in the six teaching styles (A-F) as identified by Gallagher and Parker (1995)

	A Didactic	B Transitional	C Conceptual	D Early Constructivist	E Experienced Constr.
20. Locus of decision making	• Teacher-dominated	• Teacher-controlled. Little sharing of decision making with students.	• Teacher-controlled. Some sharing of decision making with students about use of time.	• Students & teacher make some joint decisions about time and activities	• Students & teacher make many joint decisions about time and activities
21. Teaching aids displayed	• Few teaching aids displayed. May not be integrated with content	• Some teaching aids displayed. May not be related to content	• Many teaching aids displayed related to content	• Many teaching aids displayed related to content	• Many teaching aids displayed related to content. Some are made by students
22. Students work displayed	• Few examples of students' work displayed	• Students' work displayed is typically similar for all students (i.e. worksheets or identical models)	• Some variation in students' work displayed	• Students' work displayed, includes some student creations (i.e. original posters, stories, or demos)	• Students' work displayed, includes many student creations (i.e. original posters, stories, or demos)

APPENDIX B

Faculty of Science UNISA Fakulteit Natuurwetenskappe

The District Director
Tshwane South (D4)
Private Bag X27825
SUNNYSIDE
0132

Faculty of Science
UNISA
P.O. Box 392
PRETORIA
16 March 2001

Dear Sir/ Madam

Re: REQUEST FOR AN OVERVIEW OF RESEARCH PROJECT

The Faculty of Science, UNISA, under the guidance of Professor Diane Grayson (Professor of Science Education, Faculty of Science, UNISA), is involved in research aimed at improving the quality of mathematics teaching and learning at FET level.

We wish to make an appointment to discuss our research project with you.

One of the research questionnaires that will be completed by the teachers is enclosed.

Your Sincerely

Diane Grayson
Professor of Science Education

Mapula Ngoepe
Research Assistant

APPENDIX C

Faculty of Science UNISA Fakulteit Natuurwetenskappe

Enquiries: Mapula Ngoepe
Tel: 012 429 8783
Fax: 012 429 3434
E-mail: ngoepmg@unisa.ac.za

P.O. Box 392
PRETORIA
0003

Dear Sir / Madam

Re : Request to conduct research in selected schools in Mamelodi District.

The recent findings in TIMSS led to an outcry in South Africa about the performance of South African mathematics students. In addition, the National Department of Education emphasized a greater need for research to improve the present mathematics results. In an attempt to come up with solutions to this problem, there is need to conduct research with secondary mathematics teachers.

The present research entails developing a model that will integrate mathematics teachers' professional attitudes, teaching styles, content knowledge and pedagogical content knowledge. In order to facilitate the development of this model, we would like to work with several Mathematics teachers from your district in their schools without interfering with their teaching. We hope that they will feel that our research will help them improve their teaching.

This research is conducted under the supervision of Professor Diane Grayson (Professor of Science Education, Faculty of Science, UNISA).

We therefore request your permission to conduct this research in selected secondary schools in your area. Completion of this study will help to inform interventions aimed at improving learner performance in mathematics.

Thank you for your kind consideration.

Yours Sincerely

Professor of Science Education

Mapula Ngoepe
Research Assistant

APPENDIX D

Faculty of Science UNISA Fakulteit Natuurwetenskappe

Enquiries: Mapula Ngoepe
Tel: 012 429 8783
E-mail: ngoepmg@unisa.ac.za

P. O. Box 392, Unisa
Pretoria
0003

The School Principal

Re : Request to conduct research in your school

The recent findings in TIMSS led to an outcry in South Africa about the performance of South African mathematics students. In addition, the National Department of Education emphasized a greater need for research to improve the present mathematics results. In an attempt to come up with solutions to this problem, there is need to conduct research with secondary mathematics teachers.

We request your permission to conduct research in your school with your secondary mathematics teachers.

The present research entails developing a model that will integrate mathematics teachers' professional attitudes, teaching styles, content knowledge and pedagogical content knowledge. In order to facilitate the development of this model, we would like to work with grade 10 to 12 Mathematics teachers in your school without interfering with their teaching. This research is conducted under the supervision of Professor Diane Grayson (Professor of Science Education, Faculty of Science, UNISA).

Completion of this study will help to inform interventions aimed at improving learner performance in mathematics. We hope that your mathematics teachers will also benefit from working with us and lead to improved Mathematics results.

We would greatly appreciate the opportunity to work with your teachers during the course of this year.

Yours Sincerely

Diane Grayson
Professor of Science Education

Mapula Ngoepe
Research Assistant

APPENDIX E

Faculty of Science UNISA Fakulteit Natuurwetenskappe

Enquiries: Mapula Ngoepe
Tel: 012 429 8783

Faculty of Science, UNISA
P.O. Box 392
Pretoria, 0003

To: The Mathematics HOD and Teachers of Mathematics.

As a valued teacher of mathematics in Mamelodi district, you and we understand the urgency of improving the current state of Mathematics in our Province. In an attempt to come up with solutions to the high failure rate in mathematics, there is need to conduct research with mathematics teachers in their own classrooms.

On behalf of the Faculty of Science, UNISA, we therefore request you to form part of our sample. This research will be conducted under the supervision of Professor Diane Grayson (Professor of Science Education, Faculty of Science, UNISA).

The research that we request you to be part of entails developing a model that will integrate professional attitudes, teaching styles, content knowledge and pedagogical content knowledge. In order to facilitate the development of this model, we request your permission to work closely with you in your classroom for a period of one year. We do not intend to interfere with your normal teaching in any way. Among other things you will be requested to complete questionnaires, to be observed in your classroom and also interviewed on your classroom practice. In return we would be able to offer any support and assistance that we can.

The information gathered will be used for research purposes. We also hope that working with you in this research will help you to feel more confident about teaching Mathematics.

We look forward to developing a working relationship with you.

Yours sincerely

Research Assistant Professor of Science Education