Teachers learning from action: An investigation into factors influencing Grade 12 Mathematics achievement.

By

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DECLARATION

I hereby declare that:

"Teachers learning from action: An investigation into factors influencing grade 12 Mathematics achievement."

is my own work, that all sources used or quoted have been indicated and acknowledged by means of complete references, and that this dissertation was not previously submitted by myself for a degree at any other university.

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PREFACE

TITLE	Teachers learning from action: An investigation into factors influencing Grade 12 Mathematics achievement.
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The South African society is becoming increasingly more culturally diverse. It is evident, too that, as the South African society becomes more and more pluralistic, so do the classrooms. All learners who are taking mathematics as a subject are crucial to the well being of the country. Mathematical theories and models are becoming increasingly important as the basis of a variety of innovation alternatives in simulating planning and knowledge in economic and technical fields.

One of the greatest challenges is presented by the way the South African government appeals to educators to improve the Grade 12 examination results in general. To improve the pass rate, educators need to survey in which subject learners are not performing well. Mathematics is one of the subjects which learners from previously disadvantaged societies are having difficulty with.

The purpose of this study is to identify the factors that hinder the achievement of mathematics learners in Grade 12, and at the same time aims to guide and encourage mathematics educators to search for innovative methods of teaching and learning of the subject.

The research methodology incorporates a literature study. Interviews and participatory action research as qualitative research tools, were used to gather information.

Action research divided in two cycles was used to structure lesson plans. During this research it was discovered that learners react more satisfactorily to the plan of action after reflection on outcomes of lessons allowing for creativity and cooperative learning.

Parents and communities must be more sensitive to the role they need to play in education. All the stakeholders involved in education must receive appropriate training and sufficient information to be able to understand their responsibilities and give the necessary support to the schools.

The study established that some changes had to be introduced in the teaching and learning process and that pre-and in-service training were absolutely necessary for educators to direct their teaching approaches towards the requirements of the 21st century.

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CHAPTER ONE

INTRODUCTION TO THE RESEARCH

1.1 INTRODUCTION

The aim of the study is to highlight those factors that cause the low pass rate of Grade 12 mathematics learners in the Thabong township of the Free State Goldfields. It would seem proper to recall as a point of departure the words by Channing, quoted by McFarlane (1982:1): 'The great end of …instruction is not to stamp our minds on the young, but to stir up their own; not to make them see with our eyes, but to work inquiringly with their own; not to give them a definite amount of knowledge but to inspire a fervent love of truth; not to form an outward regularity, but to touch inward springs; not to burden the memory, but to quicken and strengthen the power of thought'.

South Africa powerfully illustrates the impact of political and social forces on learning and teaching in mathematics (Bishop, Clements, Keitel, Kilpatrick & Laborde 1996:1196). During Apartheid, teacher education was institutionally fragmented in universities, technikons and colleges of education and widely organized along ethnic lines. The majority of South Africa's educators have been trained in racially segregated colleges of education, most of which are academically isolated, small, poorly equipped and ineffective in the provision of quality teacher education (National Education Policy Investigation 1993:237). Enslin, quoted by Bishop *et al.* (1996:1196) explains that the governing ideology in these colleges was Fundamental Pedagogics, according to which a particular brand of ubiquitous authoritarianism in social relations and knowledge production, decepting itself by positing education as a 'science' separate from politics and human values reigned. This separation impoverished student educators to such an extent that mathematics was not a popular subject at college resulting in too few qualified mathematics educators.

In most courses for educators, education theories (including recent theories of learning) are taught by lecturers and assessed in traditional ways through essay writing and examinations. Even during practice teaching sessions in schools, student educators are expected to play the role of apprentices who are required to fit in with the school programme and show that they can teach in the ways in which it has always been done. Thus, it is hardly surprising that most qualified educators teach mathematics in the same ways as they were taught. In South Africa, there is no culture of teaching to be researched and developed in township schools, the dominant teaching culture has been shaped by the legacy of Bantu education, authoritarian practices and working relations (Bishop *et al.* 1996:1196-1198).

Research needs to extend to mathematics teaching and learning activities in the South African context, characterised by rapid political change and democratic ideals that are juxtaposed to historical inequalities and significantly limited human material and financial resources, the latter a condition in education experienced in most parts of the world.

The pass rate of Grade 12 mathematics learners must increase because South Africa is shifting from an academic to a more technological outlook where mathematics is highly emphasized. The acquisition of scientific and technological capability has become an intensely political process (Ernest 1996:92).

1.2 THE SIGNIFICANCE OF STUDY

Beliefs held by society as regards the nature and role of mathematics have a great influence on the development of the school mathematics curriculum, instruction and research (Grouws 1992:39). Some conceptions of the subject define mathematics as a static discipline, with a known set of concepts, principles, and skills (Fisher 1990:81-89). Brown, Cooney and Jones (1990:639-656) argue that distorted views are transmitted to learners and these views help shape the learners' ideas about the nature of mathematics.

Research has been done on factors influencing mathematics achievement in other countries where some factors such as novice educators, language, gender and ethnicity have been emphasized. Bromme as cited by Bishop *et al.* (1996:1169) points out that the focus of educators' work in the classroom primarily calls for a holistic and integrated view of knowledge rather than the existence of separate solutions to discrete problems. This view is supported by Berliner, Stein, Sabers, Clarridge, Cushing and Pinnegar (1988:67-95) who found that expert educators are able to process a greater array of information about learners and classroom situations than novice educators. Expert educators also demonstrate a greater range of techniques when dealing with individual learners. The assumption is therefore made that experienced educators are better mathematics educators than inexperienced educators.

Education is a human right and an essential tool for achieving goals of equity, development and peace (United Nations 1995:1). In spite of this, mathematics and related occupational fields have been clearly identified internationally as areas in which males predominate. In Britain, for example, the ratio of males and females was 2,5:1 with regard to 1991/92 (Central Statistical Office 1994:5). In South Africa the gender ratio also remains higher for the males, a fact which encourages intelligent girls not to choose mathematics as a subject. Stereotyping prevent girls from taking mathematics as a school subject.

Bishop *et al.* (1996:994) contend that much of the interaction and communication in mathematics classrooms are still predominantly symbolic and contrived. Mathematics, as presented in many classrooms, does not evolve naturally from the learners' own environments, but is dictated by adults' simplification of what they perceive to be appropriate mathematics for the learners concerned, and by the learners' reactions to and expectations of such imposition.

It is widely believed that human cognitive activity can be changed and new ways of thinking and a new human reality can be created (Ernest 1996:95). Piaget's epistemological theory is highly influential in mathematics education. Ernest (1996:95) suggests that knowledge of cognitive science must be applied to the problem, as the need for conscious evolution is becoming a necessity for all humanity. Mathematical thought is critical for all cultures. It is important to know what role mathematical thought is playing in the functioning and development of all cultures, and how each person comes to understand and participate in that role (Bishop *et al.* 1996:1170). Secada (1991: 22-56), who researched race, ethnicity and social classes, reveals that members of diverse groups interpret their membership in ways that differ from the interpretation of individuals who are outside those groups. The mathematics achievement of such groups should therefore be interpreted as a social issue rather than as a matter of individual differences. Mathematics should be taught in such a way that different groups can identify with the content. Therefore factors that hinder achievement in the case of certain groups, need to be determined.

1.3 STATEMENT OF THE RESEARCH PROBLEM

In South Africa great emphasis has been placed on Grade 12 results, especially with mathematics as a subject of which the pass rate has been on the decline since 1995. Reasons have to be found why such a career wise subject yields such a low performance level (Vinjevold 1999:8). If schools are to be places that promote self and social empowerment, then the role of the mathematics educator will have to be revisited. It is necessary for educators to develop knowledge and skills that will allow them to connect educational practice with larger social visions and to teach mathematics in such a way that learners can successfully master the subject. This implies that mathematics teaching, like all other teaching, should constantly be experimented with, new methods of teaching should continuously be explored. Kincheloe (1991:89) asserts that change is a fundamental goal of the educator as critical researcher. The question that arises is: are there methods of teaching and learning mathematics that will assist in the improvement of the pass rate of Grade 12 learners from previously disadvantaged societies?

Zumwalt, in Cangelosi (1992:21), states that many educators, instructional supervisors, and school administrators perceive a curriculum as the textbook series, adopted and mandated by the government or it is regarded as local curriculum guidelines and/or content and skills appearing on mandated tests. The belief that the curriculum comes as a parcel from someone up there, and the educator's responsibility is just to convey the bundle as it is, to the learners, could be aggravating the low pass rates in mathematics. The intention of this study it is to establish the factors which cause the low Grade 12 mathematics pass rate and to investigate innovative alternative cognitive strategies for successful teaching of mathematics in order to improve Grade 12 achievement in mathematics.

The focus of this study is on the answering the following questions:

- What factors contribute towards the poor performance of Grade 12 mathematics learners?
- What reasons are underlying the problem of the low pass rate of Grade 12 learners in mathematics?
- Can alternative cognitive development strategies be offered to remedy the problem?
- How best can all stakeholders in education be involved in solving the problem?

For the researcher to be able to accommodate educators and learners with the same interview questions, the following are the modified version of questions used in chapter three:

- What do you think are the reasons for the poor performance of Grade 12 mathematics learners?
- What reasons are underlying the problem of the low pass rate of Grade 12 learners in mathematics?
- What role do parents play in the low achievement of Grade 12 learners in mathematics?
- How best can all stakeholders in education be involved in solving the problem?

1.4 OBJECTIVES OF STUDY

The purpose of this study is to establish what factors are responsible for the low performance of Grade 12 learners in mathematics by:

- conducting a thorough literature study to establish which factors have already been identified;
- establishing and investigating which factors are hindering achievement in mathematics at secondary schools in Thabong through qualitative research;
- developing certain guidelines by mathematics educators to address or remedy the problem of low pass rates.

1.5 PRELIMINARY LITERATURE REVIEW

The announcement of the 1997 Grade 12 results was truly disastrous. Grade 12 examinations, while they may be imperfect as a valid indicator of educational accomplishments, are reasonable approximations in assessing the stage of human capital formation of 18 year-olds (Riley 1998:91). Riley (1998:91) further states that, economically, the 1997 Grade 12 results represent another step to oblivion. Van Zyl (1999:16) indicates that the 1998 Grade 12 results nationally only showed a 3% improvement on those of 1997.

To encourage learners to study mathematics and do well at it has become a matter of great concern. Carter (1991:278) states that there is a need to "resituate" science and technology in a social context. There is a growing awareness of the limits of former beliefs about cognition, that is, habits of thinking and ways of knowing which inhibited mathematics reasoning. Furthermore, Ernest (1996:95) states that it is widely believed that human cognitive activity and new ways of thinking can be changed to make mathematics a more popular subject. To help learners grow mathematically, educators are in need of a deep understanding of the content they teach. Manouchehri (1998:13) emphasizes that educators have to know learners' thinking and how the learners develop ideas; understand learners' cognitive obstacles as they encounter different investigations, and plan and realize the most appropriate teaching methods to facilitate the learning of those concepts.

The developmental changes in the ways people process information has been a cornerstone of curriculum development in mathematics. Although Piaget (as cited by Crawford 1992:161-168) recognizes that cognitive development and sensory information are influenced by experience, his theory proposes logic-genetic laws that inhibit the extent and rate of intellectual growth. Learners are not cognitively developed due to the environment and school resources in the townships, which implicates a non-assimilation and understanding of mathematics. Teaching should compensate for these disadvantages by designing teaching strategies to develop cognitive abilities.

Teaching methods are the means by which the educator attempts to attain the desired learning outcomes. Methods in teaching concerns the way educators organize and use techniques, subject matter and teaching media to meet teaching objectives and the needs of learners (Van der Horst & McDonald 1997:124). Mathematics educators' conceptions of mathematics, teaching and learning, and that what was learned from their own educational experiences, make it difficult or even impossible for them to change and act in new ways to foster a different quality of mathematics learning for learners.

1.6 RESEARCH DESIGN AND METHODOLOGY

The qualitative research approach was employed in this research. Qualitative research is an inquiry process of understanding based on distinct methodological traditions of inquiry that explores a social or human problem. The researcher builds a complex, holistic picture, analyses words, reports detailed views of informants, and conducts the study in a natural setting (Creswell 1998:15). The qualitative research approach was implemented because the topic needs to be explored, and there was a need to present a detailed view of the topic (Creswell 1998:17). The empirical research was undertaken in two distinct phases. The first phase comprised interviews through which the perceptions of interviewees on factors that cause low mathematics achievement were explored. Due to the fact that the qualitative research approach usually is associated with case studies or the improvement of practice through participatory action research (PAR), the second phase of the research consisted of PAR as component of qualitative research because it can be used to improve professional practices. PAR is an intervention in personal practice to bring about improvement (McNiff, Lomax & Whitehead 1996:16).

1.6.1 Site selected

The site selected was one public secondary school in Thabong in the Goldfields area of the Free State province. According to McMillan and Schumacher (1993:379) the site selected to locate people involved in a particular event, is preferred when the research focus is on complex micro-processes.

Typically, action researchers engage in site visits and therefore participate in direct observation and a diary of actions is being kept. In this study the PAR evolved in two cycles of action. The first cycle focused on analytical geometry and the second cycle about proportionality (Euclidean geometry). Lessons were designed by the researcher in collaboration with educators involved. Educators taught the lessons and the researcher observed. Learners in Grade 12 mathematics classes were divided into groups for class-work. Analysis was done after each cycle to obtain the results and learners and educators were interviewed to evaluate and validate the research.

The study was undertaken in two separate stages: interviews and the PAR. This had to be done because the views of the different stakeholders in education about the causes of low pass rates in Grade 12 had to be obtained through interviews. The research that was aimed at improvement of teaching methods, which was identified as a factor causing failure, was done as PAR.

1.6.2 Interviews

For the purpose of this study the free attitude interview was used. The free attitude interview is a qualitative interview technique and can be described as a non-directive controlled in-depth interview (Meulenberg-Buskens 1997:1). With the free attitude interview, the interviewees have the freedom to expand on their views and the information obtained becomes more relevant to the problem. This type of open interview provides the researchers with the type of information, which could be used to solve and identify problems in the education situation.

1.6.3 Population and sampling

The population of this study was the Grade 12 mathematics learners of Thabong Township.

A sample can be defined as a group of subjects from whom data is collected. Two classes of Grade 12 mathematics learners were used in the research, with different educators who taught each class. A sample of convenience existed of learners and educators who volunteered for this purpose. Generally volunteers tend to be "… more intelligent, more sociable, more unconventional, less authoritarian, less conforming, more altruistic, and more extrovert" (McMillan & Schumacher 1993:160). Purposeful sampling was done to select interviewees because informants who were likely to be knowledgeable and informative about the phenomena the researcher was investigating, was selected (McMillan & Schumacher 1993:378).

1.7 DELIMITATION OF STUDY

The study is undertaken in the field of Cognitive Education, which is a relatively new field of education in South Africa. The term cognitive most frequently goes with the connotation of cognitive development theories, and also invokes the meanings of intellectual abilities of learners [such as understanding, memory, etc], thinking and learning in the context of education. The broader term cognitive education is seen as teaching and learning activities which enhance, develop and build cognitive abilities of learners (Van der Westhuizen 1999:17).

The geographical area chosen is Thabong, district of Welkom in the Free State province of South Africa.

1.8 PROGRAMME OF STUDY

The study develops in the following sections:

CHAPTER TWO

RELEVANT LITERATURE REVIEW

2.1 INTRODUCTION

Technology is changing the workplace, the home and daily life. New mathematics is being created to match technological applications, which improve on a daily basis. Yet the teaching of mathematics has remained relatively unchanged. As has been the case for centuries, mathematics often relies on rote memorization (Suydam 1990:1). The objectives of mathematics education must be transformed to meet the critical needs of our society: an informed electorate, mathematically literate workers, opportunity for all learners, and problem-solving skills that serve lifelong learning. Both the content that is being taught and the way it is taught need to be reconsidered and, in many cases, transformed (Suydam 1990:1). The main focus of this research is on the factors that cause the low performance of Grade 12 mathematics learners, but notions about mathematics and its image, the importance of mathematics, some advice to parents, mathematics approaches and the deductive and inductive reasoning are also highlighted in chapter two.

2.2 MATHEMATICS AND ITS IMAGE

Mathematics has a notorious image, which simultaneously is viewed most positively and the most negatively of all subjects in the secondary school curriculum. On the one hand mathematics is considered to be the most difficult subject and is often taken by those who think of it as a status symbol. On the other hand, many parents believe that you cannot get anywhere in this world without mathematics. Oosthuizen, Swart, Gildenhuys and Laridun (1992:6) are of the opinion that these beliefs put pressure on learners to achieve in mathematics. Another misconception is that learners have a tendency to believe that mathematics is not a subject that you can study – you can either understand and do it or

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you cannot. This idea, as stated by Oosthuizen *et al.* (1992:6) results from a misconception about what "learn" means. To learn means to master something, and to be able to master mathematics implies hard work and a lot of practice.

Unfortunately, the experience many learners have during their years of schooling confirms the negative image of mathematics as cold, absolute, inhuman and rejecting. Bishop *et al.* (1996:811) state that such an image is frequently associated with negative attitudes towards mathematics. There are two sources of these myths, namely: images and conceptions of mathematics, which prevents the popularization of mathematics. Firstly, the presence of these myths is often encountered in the popular, educational and academic domain, which means that they reproduce themselves. Educators, parents and the community contribute towards this misconception. Secondly, these myths are maintained by many learners' experiences in learning mathematics at educational institutions (Bishop *et al.* 1996:811). For example, mathematics learners often ask educators to explain again because they did not understand the exercise. The educator either refuses to give another explanation or tells them to be more attentive next time. This contributes to the neglect of the subject by the learner or gives them the opportunity to say that mathematics is a difficult subject to deal with. Sleeter (1997:24) states that as long as educators frame mathematics itself as a set of isolated skills that learners need to memorise, their ability to raise the achievement of learners in pauper classrooms will be limited. Their ability to teach any learner to use mathematics as a tool for thinking will also be restricted. Research done by Zucker (1995:47-63) confirms that educators whose mathematics instruction was observed, taught mathematics in isolation of other disciplines and also in isolation of learners' real-world lives. Textbooks, worksheets, and the chalkboard were the main tools for teaching mathematics. Individual seatwork and whole-class recitation were their main teaching methods. As a result learners develop a negative attitude towards the subject.

Educators have a part to play in rejecting the existing misconceptions about mathematics. A priori, for educators and learners, is to realize that there is a need to move away from the idea that mathematics is a difficult subject. Mathematics educators need to realize that something must be done about the negative image of the subject. This injunction should begin from within the educators. Educators need to examine their attitudes and methods of presenting mathematics to the learners (Oosthuizen *et al.* 1992:6-8).

Milbourne and Haury (1999:1) explain that parents and educators can motivate learners to develop an interest in mathematics by exhibiting attitudes and values supportive of learning. Both these stakeholders must be patient with wrong answers and try new methods to explain the problem. Sometimes wrong answers, as stated by Milbourne and Haury (1999:2), will help the educator to search for more creative methods to assist the learners to rectify and understand their mistakes. Parents must motivate the children to become risk takers. This motivation may lead learners to examine the wrong answers and assure them that correct answers come with understanding.

Research undertaken in this regard by Sunday (1995:3), showed that improved mathematics performance among disadvantaged learners can be attributed to related behaviours of parents such as developing partnerships with their children's schools. Having a positive attitude towards the subject, engaging in mathematics-related activities with their children, scheduling homework routines and making sure that their children receive assistance with schoolwork when necessary, are some of the issues parents should engage in. Schwartz (1991:1) states that learner's everyday lives provide sources of mathematics knowledge, regardless of their cultural background. Asking learners to devise mathematics problems from their own experience increases their interest, concretizes the subject, and demonstrates mathematics' usefulness (Schwartz 1991:2). From an early age, they are led to believe that mathematics is a difficult subject and they grow up with a negative attitude towards the subject.

2.3 THE IMPORTANCE OF MATHEMATICS EDUCATION

In order to succeed in the modern world, learners need to be literate in mathematics and in their analogous thinking skills. As society becomes increasingly technologically oriented, mathematics as a subject opens avenues to future careers. Learners who opt not to continue with mathematics during their high school years, may limit their course and career choices at college and beyond. Rakow (1999:1) asserts that this does not mean that everyone can be a mathematician, but that everybody is affected by mathematics on a daily basis.

Mathematics underpins the workings of modern industrial society, providing the basis for science, technology and the information revolution. In a healthy democratic society the ideal will be for all citizens to be mathematics literate. That is, they should be skilled in applying mathematical knowledge and skills, be able to use such skills, be able to interpret and critically evaluate the mathematics embedded in social and political systems and claims, from advertisements to government pronouncements, from national lotteries to the stock market (Bishop *et al.* 1996:813).

According to Bigelow (1992:235) mathematics has three striking features:

- it discovers truths, which are necessary, not contingent;
- it proceeds by prior methods, and does not justify its claims by appeal to experience; and
- it has a distinctive subject matter, not material objects, nor plants, nor animals, nor thoughts and feelings, nor societies – but numbers and other things of that sort.

Taking the above-mentioned features into consideration, educators need to know which approach to employ when planning their lessons for a better understanding of mathematics.

2.4 APPROACHES TO THE TEACHING OF MATHEMATICS

Knowledge implies interaction, and human beings cannot escape from the domain of interactions, which is closed. Recently, social interaction involved in the construction of the mathematics of learners has been emphasized greatly in order to highlight the constructive aspect of mathematics (Ernest 1996:8).

There are several mathematical teaching approaches, but this study focuses only on the more popular ones, namely: Formative, Behaviourism, Structuralism, Integrated-Environmentalism, Problem Solving, Culturalism, New Maths, and Social Constructivism.

2.4.1 Formative approach

This approach has a basis in developmental psychology and focuses on the natural process of personal development. Neyland (1995:39) states that it is entirely learner-centred and aims to match learning opportunities in mathematics with the learner's natural cognitive abilities. For example a Grade 4 learner will do Grade 4 mathematics and not mathematics for Grade 6.

2.4.2 Behaviouristic approach

Behaviourism has its origins in educational psychology. This approach was designed to transform education from a labour-intensive to a capital-intensive process. The idea is to carefully organize school mathematics into a precise sequence of small steps, in such a way that the learning path will be exploited optimally. The approach is focused on the output, the end points of learning on what people can do, rather than merely on understandings and meanings that have been achieved. Unfortunately, the behaviourist techniques do enable the efficient achievement of low order skills, but their use on a more widely basis inhibits the learner's intuitive construction of ideas and examination of misconceptions (Neyland 1995:36).

2.4.3 Structuralist approach

This approach has its origins in both mathematics and psychology. The psychological focus is based on theories of cognitive development and concept formation. The mathematical focus is based on theories about structures which underpin mathematics (Neyland 1995:38). Dieudonne, in Anglin (1995:52), professed a structuralist epistemology of mathematics, in the sense that mathematics is viewed as interplay and comparison of patterns. As a structuralist, Dieudonne (1992:162) views mathematics as a unified whole, in which the meaning and significance of every part is a function of the role it plays in this whole.

2.4.4 Integrated-Environmentalist

The Integrated-Environmental approach is based on the view that mathematical knowledge cannot be separated from the contexts from which it is extracted and from which it achieves its meaning. Mathematics is seen as a strand of concepts, which can be discovered by exploring problems in the environment. The learner's environment is used as a source of inspiration and meaning, and as the base for the abstraction process (Neyland 1995:40). When an educator wants to explain the volume of a cylinder, he/she can take learners to silos. The learner can observe the configuration of such silos and associate it with a cylinder. The next time a question is asked about this figure is asked the learner will vividly remember the example the educator gave of it.

2.4.5 Problem-Solving

Problem solving involves applying mathematics to the real world, serving theory and practice of current emerging sciences (Ernest 1996:175). It thus begins to acquire a social context, frequently referred to as "communication" in addition to a continuous focus upon real world applications.

Problem solving, it is believed, would achieve several educational goals. It emphasizes mathematical processes as well as the mathematical content. This approach uses problem-solving strategies, namely: "solve a simpler problem first", "work backwards" and "try extreme cases" as key processes within mathematics (Neyland 1995:42). Ideally, learners should share their thinking and approaches with other learners. That is, learners should learn to value the process of solving problems as much as they value the solution (Ernest

1996:175). It concurs with the educational principle of starting from the simple and progressing to the complex (inductive approach).

2.4.6 Cultural

The cultural approach is not reflected in typical classroom practice. It represents the educational aims of the small group of teachers who work with indigenous people. This approach is based on the belief that all cultural groups engage in activities, which exhibit mathematical elements. Thus the cultural approach views mathematics as a social and cultural product based on certain activities (Neyland 1995:43). Educators can associate many geometric figures with cloth patterns, especially with the traditional clothes of Blacks of African desert.

2.4.7 New Maths

This approach to teaching was an attempt to radically improve mathematical attainment. It was thought that giving the subject a foundational, conceptual, unity would be a major step towards achieving this goal. Unfortunately, although improved achievement was the aim of this movement, pedagogical issues as such were given insufficient attention. This approach was never fully accepted (Neyland 1995:34-36).

2.4.8 Social Constructivist

The main focus of this approach is that it acknowledges that both social processes and individual sense making have central and essential parts to play in the learning of mathematics (Ernest 1996:63). Social constructivism has, as Neyland (1995:45) points out, two focus points: firstly, the belief that education in general, and mathematics teaching in particular, should be aimed at encouraging learners to see the future as something they can have a part in creating. In the second instance approach takes an evaluative orientation towards the uses and the place of mathematics in society. Social culture has selected for attention (Van Niekerk 1996:125). With this in mind, it is conspicuous that learners' errors on word problems are very often remarkably systematic (De Corte & Verschaffel 1991:105-114). These errors result from the misconceptions of the problem situation, which are the result of insufficient mastery of the semantic schemes underlying the problems. These words prompt one to think deeper about the causes of the low pass rate of Grade 12 mathematics learners in South Africa (especially in the case of learners from the township schools).

2.5.2 Gender equity

Females around the world still face discrimination (Bishop *et al.* 1996:946). Gender, class and ethnicity affect educational opportunities. For example, in the Arabic countries girls are not allowed to pursue mathematics as a subject. The cultural upbringing of a child also influences which subjects the child will take later in life. The impact of these factors differs across industrialized and developing countries. Completing secondary education is more likely for females from socially advantaged backgrounds than for males from families in poverty (Bishop *et al.* 1996:946). Furthermore, participation in education by females does not guarantee their access to all disciplines. In Iran, for example, women are denied entry to many science-related fields of endeavour (Paivandi 1994:68-78).

Limited mathematical background continues to block many occupational options to people in Western industrialized nations. Statistics in the United States of America and elsewhere reveal that women are under-represented in the most advanced mathematics courses (Milbourne 1999:1). When enrolments in the most demanding mathematics subjects are examined at school level and in higher education, gender imbalance is evident, that is more males than females have been enrolled (Bishop *et al.* 1996:946). In addition, separate statistics for males and females are often unavailable in developing countries. Graham-Brown, as quoted by Bishop *et al.* (1996:947) explains that in the middle-1980s it was estimated that there were seven males for every female enrolled in African Universities, and that women were grossly under-represented in natural science and engineering courses. For instance, in mathematics classes with thirty learners, on average only five are female and the rest are male. A similar pattern of tertiary enrolments was reported more recently for Papua New Guinea by Kaely (1995:91-97), for Singapore by Kaur (1995:129-134), and for Malawi by Hiddleston (1995:147-152).

The fact that females are under-represented in the world of mathematics underlines a factor that can contribute to underachievement.

An interesting feature in this regard pertains to factors that influence the underachievement of girls in mathematics.

Beginning at a young age, many girls and boys receive different messages from parents, peers, educators and the media. Young girls are taught to nurture, while boys are encouraged to play with toys. Boys can tinker with or manipulate construction sets, such as Lego, building blocks and tool kits. Playing with these toys provides opportunities to develop the problem-solving and independent-thinking skills inherent to success in mathematics. Girls who lack these skill-building experiences often enter mathematics classes feeling insecure about their abilities (Milbourne 1999:2).

Self-perception plays an important role in mathematics achievement, especially for girls. Research shows that self-esteem and academic achievement among girls begin to decline during middle school and that girls often exhibit a loss of self-confidence by age 12 (Backes 1994:19-23). Furthermore, Milbourne (1999:2) states that this lack of self-confidence is also reflected in the fact that boys are more likely to attribute personal success to effort, whereas girls tend to attribute it to luck. As a result, many girls underachieve in mathematics simply because they choose to participate in activities in which success is almost guaranteed.

Mathematics curricula often exploit the differences between males and females by drawing on their early play experiences. Action toys for boys teach core mathematics concepts, such as: velocity angles, three-dimensional configurations, while girls usually experience these concepts for the first time in a classroom (Schwartz & Hanson 1992:2).

2.5.3 Social and cultural issues

Learners from low-income or one-parent households, or from families with an unemployed parent, are more likely to be assigned to low ability groups (Davenport 1993:4). There are two ways of grouping, that is: between-class grouping and within-class grouping. Between-class grouping refers to a school's practice of forming classrooms that contain learners of similar ability. Within-class grouping refers to an educator's practice of forming groups of learners of similar ability within an individual class (Davenport 1993:1).

Until recently, there have not been many links to learners' culture in the mathematics classroom. Strutchens (1995:1) says that this may be one of the major barriers to achievement of many historically disadvantaged learners being under-represented in mathematics. Banks, in Strutchens (1995:1), claims that preparing learners to be functional in a competitive, pluralistic society and teaching them about their customs, heritage, history and other aesthetic aspects are essential components of an effective education programme. Stolp (1994:1) asserts that healthy and sound school cultures correlate strongly with increased learner achievement and motivation, as well as with educator productivity and satisfaction. School culture also correlates with educators' attitudes towards their work. In a study that profiled effective and ineffective organizational cultures, Cheng (1993:85-110) found that stronger school cultures had better motivated educators. In an environment with strong organizational ideology, shared participation, charismatic leadership and intimacy, educators experience higher job satisfaction and increased productivity.

Researchers, such as Kaaya (1990:92) who explore the parental influence on mathematics achievement in black population areas, finds that the educational and vocational aspirations which black parents have for their children can predict how well these learners will do in mathematics. It appears that parental expectations communicated to learners is a very powerful tool to motivate learners achieve because parents believe in them. This, in turn, strengthens the learner's belief in the parents (Sunday 1995:3).

Mathematics educators actively look for ways of linking mathematics and the South African multicultural society, with all its different cultures (Bishop 1988:179-191; D'Ambrosio 1985:44-48; Frankenstein 1990:336-347; Zaslavsky 1993:45-55). The five dimensions of multicultural education, identified by Banks (1994:4-5), provide a framework for empowering all learners through a mathematics programme that accommodates all cultures:

- **Content integration**, the illumination of key points of instruction with content reflecting diversity;
- **Knowledge construction**, helping learners understand how perspectives of people within a discipline influence the conclusions reached within that discipline;
- **Prejudice reduction**, efforts to develop positive attitudes towards different groups;
- **Equitable pedagogy**, ways to modify teaching to facilitate academic achievement among learners from diverse groups; and
- **Empowering school culture and social structure** ensuring educational equality and cultural empowerment for learners from diverse groups.

Learners should understand the role of mathematics in a multicultural society, that is, to share the views of others and respect the ways they perceive it and use it to comprehend.

2.5.4 Socio-economic factors

Many families face monumental strain associated with their daily routine, mainly because of economic factors. Kagan (1995:1) states that a stagnant economy routinely demands family employment in two or three jobs, leaving little time for effective parenting. Job insecurity often creates family discontinuity and fragmentation. Unemployment is causing more and more parents to face complexities that make nurturing children difficult. Finally, the rise in the number of single parents, places a heavy burden on families and on society. Parents in the townships are facing retrenchments due to closure of mines or other companies that cannot support the economic inflationary trend, which implies that learners do not enjoy the financial security which they need in order to achieve academically.

Research done by Gelles (1989:492-501) reports that economically deprived single mothers are more likely to abuse their children physically and that premature low-birthweight babies born into poverty have a poorer prognosis of functioning within normal ranges (Bradley, Whiteside, Mundfrom, Casey, Kelleher & Pope 1994:346-360). Duncan, Brooks-Gunn and Klebanov (1994:296-318) assert that family income and poverty are powerful correlates of the cognitive development and behaviour of young children. However, Roberts and Wasik (1990:274-284), Seitz and Apfel (1994:677-683) conversely, state that when economic conditions of families improve, or when services such as parent education and support are offered, outcomes for children, siblings, and families improve.

Parents with low income or who are unemployed have difficulty in acquiring support material for their children. Mathematics is a subject, which requires parents to buy scientific calculators for learners to solve exercises. According to Smith (1999:1) learners with calculators have access to a wider range of complex problems, and they are able to address these problems earlier in their school experience. Learners at all levels should have access to calculators and other technology as they solve problems. Research affirms the positive impact of calculator use on the development of problem solving strategies and performance (Smith 1999:1).

Teaching mathematics for deep understanding in high poverty classes, Zucker (1995:48) notes that educators need to re-conceptualise mathematics in at least one of two ways: "(1) orienting curriculum and instruction toward conceptual understanding of mathematical ideas and procedures, and (2) broadening the range of the mathematical content studied". In other words, educators should learn to view and then teach mathematics in terms of deep concepts rather than rote skills, and also to connect mathematics with real life problems that engage their learners in thinking activities.

2.5.5 Mathematics educator shortage

Over the past decades, societal needs for scientific and technical knowledge have led to increased concern for the teaching of scientific subjects in school (Bishop *et al.* 1996:1123). Although this has played out differently across countries, one common objective has been not only to increase the number and quality of scientists, but also to broaden the scientific understanding common to the whole population. Despite repeated efforts to reform instruction and the curriculum, observers in many countries agree that difficulties regarding the shortage of mathematics educators are not being overcome (Bishop *et al* 1996:1123).

In South Africa, it is mainly the previously disadvantaged schools that experience serious shortages of trained mathematics educators. During the apartheid era in South Africa, the majority of educators had been trained in racially segregated colleges of education, most of which were academically isolated from white colleges. These colleges were small, poorly equipped and ineffective in the provision of quality teacher education (NEPI 1993:237). The wide gap in qualifications between the white and black educators, as well as the large learner-educator ratio in township schools, contribute towards poor achievement of the black learners in the township schools. Whereas a great number of white secondary mathematics educators have a degree that includes some tertiary mathematics, the vast majority of black secondary mathematics educators have a three-year post school teaching diploma – often with very little post-secondary mathematics (Bishop *et al.* 1996:1196).

In a study that was done, revealed that schools often place their least qualified mathematics educators in low-ability classes and their most-qualified educators in their high-ability classes, particularly at the secondary level (Davenport 1993:2). Cangelosi

(1996:7) asserts that most learners will lack some or other mathematical skill that is a prerequisite to what is to be taught to them, althought the gaps will vary from learner to learner. Furthermore, many learners, although lacking some skills, have already acquired an understanding of some advanced topics that the educator is expecting to introduce. This implies that educators should anticipate pre-knowledge especially in low-ability classes, but these learners usually are not taught by the best educators.

Bromme, in Bishop *et al.* (1996:1169), states that the focus of educators' work in the classroom primarily calls for a holistic and integrated view of knowledge, rather than the existence of separate solutions to discrete problems. This view is supported by Berliner *et al.* (1988:67-95) who claim that expert educators are able to process a greater array of information about learners and classroom situations than novice educators. The former group can therefore demonstrate a greater range of techniques for dealing with individual learners. Pre and in-service programmes can overcome this problem with experts of all fields sharing their expertise with less experienced educators.

2.5.6 Pre and in-service programmes in South Africa

Apartheid produced an unforgivable representation of quantitative and qualitative educational neglect; at the same time it was opposed to developing educational activity of black educators, which included in-service professional development of mathematics educators and action research projects (Bishop *et al.* 1996:1197). Very little was done in this regard during the apartheid era. For the educator who wants to be consistent with the emphasis that learners need to construct mathematical knowledge for themselves, Brown (1994:81) suggests the following:

- educator must learn to communicate mathematics terminology with learners;
- educator must learn how to organize possible mathematical events;
- educator must learn how to foster reflection and abstraction in the context of goal directed activity; and

- educator must learn how to encourage learners to communicate mathematically amongst themselves.

The above-mentioned approach to facilitate learning does not apply to novice educators only, but also to experienced educators, who now have to apply the outcomes-based approach to teaching and learning.

One of the purposes of the practical teaching unit, which forms part of the pre-service training of educators, is to allow student educators to see how other educators go about teaching mathematics (Oosthuizen 1992:90). The more educators the student educator observes during the teaching practice sessions the better. Once student educators enter teaching themselves, post experience will influence their ideas and approaches to many practical aspects of teaching the subject, such as lesson design, teaching techniques, classroom management and assessment techniques.

The Department of Education and Vista University provide ample support in the form of workshops and action research as a form of in-service training in Free State Schools. In an effort to approach and comprehend mathematics in a meaningful way and also to apply mathematics to address real-life situations, educators are expected to implement deductive and inductive reasoning skills in the process.

2. 6 DEDUCTIVE AND INDUCTIVE REASONING

The deductive and inductive strategies are well exploited as the dominant strategies of teaching mathematics. In a sense the one is the antithesis of the other. The principles underlying these two strategies are fundamental, so that they form the basis of all contemporary approaches in teaching (Van der Horst & McDonald 1997:124).

The deductive method begins with a specific set of assumptions and attempts to draw conclusions or derive theorems from them. It is a logical operation, which proceeds from the general to the particular. Deductive reasoning shows that a statement is true by using the given information, previously defined and undefined terms, theorems or statements assumed to be true, and logic. A conclusion based on deductive reasoning must be true if the hypothesis is true. For example, educators use deductive reasoning to show that the sum of the measures of the interior angles in every triangle is 180^o. Another example, if a = b and b = c, we can deduce that a = c (Billstein, Libeskind & Lott 1997:581).

The educator who uses the deductive strategy begins by giving his/her learners a general statement, rule, law, theorem or principle, and goes on to apply this to specific cases or instances. The learners' active participation is confined to the application of the given statement, rule, et cetera, to numerous examples. The deductive strategy is used extensively in mathematics and also in other learning areas. However, for lessons where learners need to make discoveries for themselves, the inductive strategy is preferred (Van der Horst & McDonald 1997:125). Some studies and experiences show that, although children are good at inductive reasoning, that is, making generalizations from specific cases, they are poor at deductive reasoning because so few of the generalizations they hear at school have been internalised, that is, made their own.

Billstein *et al.* (1997:581) state that the inductive strategy is implemented by scientists make observations and proposes general laws based on observations and patterns. While inductive reasoning may lead to new discoveries, its weakness is that conclusions are drawn only from the collected evidence. An example of inductive strategy is: after completing a homework assignment in which a learner used a protractor to measure the angles of six triangles, the learner concluded that the sum of the angles in a triangle is 180^o. In practice the inductive and deductive methods of reasoning are used in natural sciences to prove statements.

2.7 SMALL GROUP TEACHING AND COOPERATIVE LEARNING

To show the significance of language in mathematics education, Pirie (1991:143-161) denotes the following about small group teaching and cooperative learning:

- When learners are involved in cooperative learning, they use language when trying to put newly acquired knowledge into their own words, as well as when they are trying to test their ideas and ways of thinking on fellow group members.
- In group work, skills such as the ability to express a point of view, the ability to engage in discussion, logical reasoning, probing and questioning and the ability to speculate creatively are very important, yet they all have an element of language in them.

In addition to the above, Pirie (1991:143-161) defines discussion (with regard to mathematics) as a purposeful talk on a mathematical subject in which there are genuine learner interaction, and this immediately brings language into play. Everything considered, language is central in cooperative learning of mathematics.

2.8 CONCLUSION

All innovation has a context and a place. The first and most obvious conclusion seems to be that all educational change has a social, political and economic context. This is particularly true of curriculum innovation in subjects such as mathematics, which is widely perceived to have direct benefits for the national economy and for personal and social mobility.

To improve the mathematics image, every educator (primary and secondary school) has a role to play in eliminating the misconceptions that exist concerning mathematics. The mathematics done at school is not necessarily as difficult as people purport it to be. Any educator who is serious about the subject, can by means of their approach and presentation, make mathematics easier to assimilate by improving the quality of his/her teaching. Through thorough preparation, approaches can be developed for the introduction of new concepts in ways that make it easier to understand. The most important characteristic of a successful lesson is not what is taught, but how it is taught.

Parents and educators must work together and motivate learners by arousing an interest for mathematics. Learners should be assisted to recognize the use of mathematics around them in their daily lives, and engage themselves in games and activities that foster familiarity with numbers and mathematical thinking (Milbourne & Haury 1999:1).

The approaches to the teaching of mathematics, mentioned under 2.4, are used regularly and depend mostly on the content to be taught, pre-knowledge required and which needs to be recalled, and the philosophy of life the educator holds. The application of these approaches thus varies among educators. However, in one way or another all these approaches are used in the teaching and learning of mathematics.

All mathematics educators must be well aware of the factors that can influence the performance of the learners in this subject. It is strongly recommended that educators discuss the matter with other mathematics educators in an effort to minimize the problem.

For educators, the pressures to change to more active and reflective forms of teaching mathematics through processes of investigation and problem solving will indeed present a challenge. Action research has the potential to both support change in professional practice and provide appropriate active learning opportunities for educators.

South Africa is a country in which there are numerous social, cultural and vocational changes in progress. In times of change new forms of learning are needed that allow for the necessary reflection, problem definition, experimentation and problem resolution that forms an essential part of human adaptation. A key element in achieving such changes will be changes in the learning experiences of educators, through their active involvement in a process of research-based change in educational institutions.

Chapter three deals with data analysis and reporting, that is, the outcomes of the research. Mathematics lesson plans prepared for Grade 12 learners with the intention to improve performance in the subject, are provided in the Annexes.

CHAPTER THREE

DATA COLLECTION AND REPORTING ON INTERVIEWS

3.1 INTRODUCTION

A detailed literature review relevant to the possible factors underlying the poor performance of Grade 12s in mathematics has been discussed in the preceding Chapter.

This chapter includes of data collection and reporting based on the outcomes of the interviews. The PAR conducted is explained and reported on in Chapter four.

3.2 METHODOLOGY

The qualitative approach was chosen for this research. This approach presents facts in a narration with words and is based more on a naturalistic-phenomenological philosophy, which assumes that multiple realities are socially constructed through individual and collective definitions of the situation and it is further concerned with understanding the social phenomenon from the participants' perspectives (McMillan & Schumacher 1993:14-15).

The aim of qualitative investigation is to gain an understanding of a concept (s) us viewed by participants and influenced by their social realities. The concepts are "grounded theory" because these abstractions are derived from observations rather than deduced from prior theories (McMillan & Schumacher 1993:376). The grounded theory approach was applied. The basic tenet of the grounded approach is that, a theory must be grounded in the data. Hence the approach purports to be inductive rather than deductive. As defined by two of its major proponents, Strauss and Corbin (1990:24), the grounded theory approach is a qualitative research method that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon. The intent is to develop an account of a phenomenon that identifies the major constructs, or categories in grounded theory terms, their relationships, and the context and process, thus providing a theory of the phenomenon that is much more than a descriptive account (Becker 1993:254-260). In this study the grounded theory is linked through observations.

3.3 DATA COLLECTION

At the start of a study, which is the most critical point of research, it is imperative to determine what is to be achieved. McNiff *et al.* (1996:39) are of the opinion that the difficult choice is about selecting small parts of data to use for particular purposes, like providing answers to research questions.

The interview questions to be put to interviewees in this chapter has been mentioned under 1.3 earlier on. These questions were posed to all the interviewees, that is, educators and learners:

- What do you think are the reasons for the poor performance of Grade 12 mathematics learners?
- What reasons are underlying the problem of low pass rates of Grade 12 learners in mathematics?
- What role do parents play in the low achievement of Grade 12 learners in mathematics?
- How best can all stakeholders in education be involved in solving the problem?

There are primarily five instruments for collecting data, namely, observations, interviews, documents, tests, and unobtrusive measures (McMillan & Schumacher 1993:40). Qualitative research usually treats the records of ideas about these research events and reflections on them as data (NDU*IST 1999:1).

In qualitative research, data is collected from the empirical world. Such data then forms the basis for conclusions about the empirical world. Any set of data is, in fact, a subset of possible data about any phenomenon, and many of the key issues in data collection across all research traditions address the problems inherent in using a subset as a stand-in for a larger data universe (Bradley 1993:439).

For this study, free attitude interviews were chosen and conducted with the intention of obtaining the most open, accurate and informative responses possible. The free attitude interview is a qualitative interview technique and can be described as a non-directive controlled in-depth interview (Meulenberg-Buskens 1997:1). Josselson (1993:ix) describes in-depth interviews as follows: "Listening to people talk in their own terms about what had been significant in their lives seemed to us far more valuable than studying preconceived psychometric scales or contrived experiments".

In interviews it is assumed that there is an interviewer and one or more interviewees. In this study interviewees were encouraged to speak freely and could ask questions about uncertainties. The purpose of the interview was to probe the ideas of the interviewees about the phenomenon of interest (Trochim 1999:2). In the case in hand the focus was on factors that influence Grade 12 performance and reasons underlying low performance.

3.3.1 Interviews

Interviews were conducted with learners and educators. All data was kept confidential and no names were mentioned. The free attitude interview was used especially to give the educators and learners the opportunity to feel free when answering questions and even to extend their points of view.

3.3.2 Interviewees

The sample that was interviewed consisted of two mathematics educators and three Grade 12 mathematics learners. The interviews were conducted individually and the questions posed were the same for all the interviewees. The educators, their academic achievements and years of experience in the field of teaching, established credibility. The period of experience was five and seven years in the teaching profession.

3.3.3 Ethical considerations

Permission was obtained from the Department of Education for research to be done at the side previously identified. The participants were asked to participate in the research and it was made clear that they were not merely "subjects" being studied by the researcher. The researcher was investigating herself in relation to them and as qualitative researcher thus became fully "immersed" in the situation (McMillan & Schumacher 1993:15). This study will be published for the sake of other educators to have access to it and to modify their teaching, as well as their mode of planning mathematics lessons and learner activities if necessary.

3.3.4 Limitations of study

Educators and learners usually feel threatened when confronted with research. In the second instance the credibility of secondary data, which includes the departmental statistics on the school, was a limitating factor because the department could not provide a breakdown of statistics per subject in higher grade or standard grade. Furthermore only one school was chosen to conduct the research. Lastly, based on the aforementioned remarks, the research findings will not be generalisable.

3.4 DATA ANALYSIS

Qualitative data analysis is a term applied to a range of methods for handling data that is relatively unstructured and that cannot be appropriates by quantified. Researchers using such data usually seek to gain a new understanding of a situation, experience or process; learning from the detailed accounts that people give in their own words, or that the researcher records in field notes from participant observation or discovers in documents (NUD*IST 1999:1).

Qualitative data analysis is primarily an inductive process of organising the data into categories and identifying patterns among the categories (McMillan & Schumacher 1993:479). Mertens (1998:348) states that data analysis in qualitative studies is an ongoing process, which has sometimes been portrayed as a somewhat mysterious process in which the findings gradually "emerge" from the data through some type of mystical relationship between the researcher and the sources of data.

Inductive analysis as Patton (1990:390) asserts, means that the patterns, themes and categories of analysis emerge from the data rather than being imposed on them prior to data collection and analysis. A natural creation of categories, according to Dey (1993:99), usually develops with the process of finding a focus for the analysis, and reading and annotating the data.

Care has been taken to protect the anonymity of both educators and individual learners as Welch (1999:19) recommends. The interviewee's names are not revealed to ensure confidentiality and to protect privacy.

3.4.1 Coding of data

Case analysis usually initiates data analysis; therefore, the constant comparison method was implemented (Patton 1990:376). The researcher firstly did cross-case analysis of the five interviews, to group answers, to identify common issues and analyse different perspectives on central issues. The responses were analysed and categorised. The gist of all responses was then presented in summarised concepts.

3.5 REPORTING ON INTERVIEWS

For each question the summarised and combined responses of interviewees are given whereafter the researcher provides own comments.

The first question was asked to ascertain why Grade 12 mathematics learners performed poorly.

QUESTION 1 – What do you think are the reasons for the poor performance of Grade 12 mathematics learners?

- **Poverty:**

Respondents deemed economic factors important. Educators focus on it due to the fact that many parents are unemployed therefore the learners cannot undertake educational tours; consequently their scope of knowledge cannot be broadened. The learners were mostly worried about what they were going to eat, wear and how to further their studies if their parents are unemployed.

Researcher's comment: The researcher noticed the sadness of the educators and especially learners when they were talking about the sensitive issue of unemployment. The learners experience a lack of concentration due to malnutrition, which causes them to become very tired and unable to cope with lessons after break. In this regard mathematics educators have to adhere to the words quoted on 2.5.4 about how to teach mathematics for deep understanding in high poverty classes.

- **Level of literacy:**

Lack of education on the parents' side is a factor mentioned by the educator respondents. Educators emphasised that parents are most often not well educated and are unable to assist learners with their schoolwork. These respondents also said that parents sometimes are not aware of their responsibility or do not even feel inclined to instill in their children the necessary discipline to study. Two of the learner respondents replied that their parents are not educated, hence are not able to help them with their schoolwork. The third learner said that his parents assisted him with schoolwork during his primary education, but they are incapable of doing so at the secondary level (cf. 2.5.3).

Researcher's comment: Learners experience lack of support from their parents. The parents' lack of knowledge leads to ignorance and to neglect of responsibility. Due to low socio-economic status, learners find themselves with a lot of responsibilities at home, and thus have insufficient time to attend to their studies after formal school hours.

Crime/violence and drugs also play a role in their poor performance because of insecurity, fear and uncertainty.

- **Language:**

The language factor cannot be over-emphasised. From the responses two of the educators it became clear that learners have difficulty in understanding the questions. When the educators are dealing with content, they need to use very simple English and are compelled to provide synonyms of mathematical terms in their mother tongue. One of the educators answered that some learners enter the secondary school unable to construct a simple English sentence, which emphasises that those learners will have difficulty with understanding explanations given in class. Learners struggle when they are instructed in a language, which is not their mother tongue. Learners responded that they do experience problems with English as language of learning. Even after the educator had tried to explain the problems in simple words, and highlighted the key words for learners to focus on, they still did not understand. One learner suggested that they would perform better if mathematics could be taught in their mother tongue (Southern Sotho). The other two learner respondents were of the opinion that mathematics has its own concepts which must be explained in English, because English is seen by them as an international language.

Researcher's comment: Mathematics does have its own characteristic language and terminology, which becomes difficult for learners to comprehend when it is taught through a second language. Mathematics educators need to be aware that much of the language used at the level of interpersonal communication, differs from the language used in education and that learners may be more proficient in the one than the other. Educators were very frank in their responses about language because they struggle with the language problem in the classroom on a daily basis. Learners displayed frustration and confusion when they talked about language, because they felt that if they could master English they would be able to perform much better academically.

- **Inadequate pre-knowledge:**

Another facet mentioned by respondents was inadequate pre-knowledge. Educators were prompt to emphasise those inadequate pre-knowledge leads to a struggle in dealing with the mathematical concepts at Grade 12 level. Educators mentioned the issue of educators in earlier grades not finalising syllabi, together with promotion on age, makes it difficult for learners to understand the interrelationship between the numerous aspects of the content. With regard to pre-knowledge the learner respondents were a little evasive because they said that sometimes in the higher grades, the educator refers them to the chapters which were supposed to have been taught in earlier grades. Two of the learner respondents went a little further and mentioned that some educators in the higher grades teach content from earlier grades to provide the learners with some pre-knowledge. Only then does the educator start with the new content, which implies that learners have to study more content than they are suppose to.

Researcher's comment: Educator responses once more highlighted the lack of proper training of educators in disadvantaged schools. Lessons are not planned around pre-knowledge. Therefore learners lack the sequence of development and exposure to new concepts, because new knowledge cannot be integrated with previous knowledge. Learner's prior knowledge determines what they learn and how they perform.

- **Delivery methods of mathematics:**

Another aspect that the educator respondents mentioned was teaching methodology: One of the educators said that mathematics educators in general, "teach the subject as if it is a bag of tricks which learners have to memorise" (cf. 2.2). According to this approach the educator does most of the thinking and learners just have to remember the steps; in short problem-solving skills are generally not taught. This they claim is due to fact that some mathematics educators were not trained to teach mathematics. Learner respondents did not mention anything about methodology per se. They just commented that they understand some educators better than others, but without naming the reason.

Researcher's comment: Educators do not have their lesson plans prepared, which implies that a sound methodological approach is not applied. Educators only use the textbook and implemented the examples from it. Steps involved in addressing problems in the exercises are the same way as they were taught at school, which completely lacks any form of creativity. Homework and classwork follows the same pattern and they do not require the learner to go to the chalkboard.

- **Negative attitude**

Respondents pointed out that negative attitudes were another factor that had a negative bearing on Grade 12 performance. Both educators commented on the attitude of learners towards their studies in general and towards mathematics in particular, which partially explains learners' class poor attendance, their mathematics and the way in which they exert themselves. Educators commented that since primary school children disliked the subject due to various reasons, they were not motivated to produce their best. The educator interviewees were lamenting on the fact that educators, parents and the community were not fully aware of the detrimental consequences of a negative attitude towards mathematics and its influence on the socio-economic development of the country. There are too few learners who pursue mathematics at secondary school level in preparation of future studies at tertiary level. All the learner respondents said that they are very fortunate to study mathematics as a subject, which affords them the opportunity to pursue further studies at tertiary education level. They commented that most of the learners in their community chose other subjects, due to the fact that mathematics is perceived to be very difficult.

Researcher's comment: The educator responses as regards unsatisfactory class attendance of learners and the general practices of mathematics emphasise the negative attitude that learners have towards their studies and mathematics in particular. On the other hand learner respondents reveal that the majority of learners are choosing other subjects due to the fact that mathematics perceived to be difficult.

The following question was asked to ascertain the possible reasons underlying the Grade 12 mathematics learners' underachievement.

QUESTION 2 - What reasons are underlying the problem of low pass rates among Grade 12 learners in mathematics?

- **Inadequate pre- and in-service teacher training:**

Responses by educators point to a case of inadequate pre-and in-service training. Wrong beliefs about how learners learn mathematics and the situation in the training colleges where a student educator has to do all the subjects and later teach them, were strongly emphasised. The educator respondents expressed great concern regarding this issue and mentioned the urgent need for authorities to speed up the procedure. Learner responses focused on not understanding the explanations of educators, especially in the lower grades.

Researcher's comment: Student educators are not receiving a sound pre-and in-service training at certain institutions. The educator respondents made the researcher aware of the problem that the student educators had to face when they are compelled to do all the subjects of the curriculum. When they finalise their teaching training, the responsibility of these educators is that they have to teach all subjects even if they are unable to master them well. Very few student educators join teaching for natural science subjects. They seemingly lack a sound knowledge about how to present the subject in an interesting and motivated way.

- **Second language instruction:**

Language was mentioned again as one of the reasons for the low pass rate of Grade 12 learners in mathematics, which stresses the importance of language in learning. The educator respondents emphasised that it is problematic for learners to learn mathematics through the second language since many of them are not proficient in English, which serves as the language of instruction and learning. Learner respondents pointed out that when they attempt to answer a question paper, they sometimes find it difficult to understand the questions. It is only after the educator explained to them what is asked, that they are able to answer. All respondents agreed that language is a barrier, which they have to overcome to achieve academically.

Researcher's comment: The method of teaching used by educators whereby learners are not allowed to talk and practice in their own languages in class aggravates lack of understanding. When they reach the final grades, where learners really have to use the language to internalise and test their ideas, they have a problem in communicating, explaining and expressing their thoughts. The Department of Education in the Free State requested that learners should be taught in English in township schools, unless it was the mother tongue subject.

- **Deficient knowledge of prior grade information:**

From the educators' responses it is clear that pre-knowledge was once more emphasised and they indicated that mathematics learners reach Grade 12 with deficient pre-knowledge. The "best educators" are almost always reserved for Grade 12 learners; and more often than not at that stage, it is too late to mend the damage done in the lower grades. Learners express the wish that the "good educators" should teach the subject at all grade levels.

Researcher's comment: Researcher observed the reluctance of the educators when they were talking about the "best educators". Unfortunately time is very short to remedy and help the educators in lower grades, but what the respondents answered is true, that the best educators are reserved for the higher grades. Learners are hampered by an inadequate foundation in mathematics, namely basic skills and the interpretation of questions. Furthermore, a lack of pre-knowledge snowballs right from primary school days, due to the fact that educators are not completing their syllabi and learners' lack of understanding of previous content, which in essence form the foundation for further learning.

- **Distorted mathematics image:**

Responses of the educators made it clear that the image of the subject mathematics is very distorted. In this regard one of the educator respondents mentioned that educators and parents sometimes say that a certain part of mathematics is very difficult. Thus, a negative message is conveyed to the learners concerning the level of difficulty of mathematics. The learner responses were not clear in this regard and only two mentioned that "everybody knows that mathematics is very difficult" and that those learners that are able to successfully complete their Grade 12 with this subject, are the ones who have greater opportunities to secure a job.

Researcher's comment: Researcher noticed that educators and learners were not comfortable when mention was made of this issue. The problem starts from an early age where every other subject except mathematics seems to relate to the children's everyday life. A mathematics educator must show love for the subject and explain it in a simple way.

- **Teacher -learner relationship:**

The educator respondents were of the opinion that the relationship between educators and learners were not conducive to learning. One of the educators even quoted that "learners do not respect educators". This respondent added that if an educator commands respect in a classroom the learners will perform. The other educator mentioned that since corporal punishment was taken out of schools, learners tend to disobey educators and be unruly. Two of the learners were of the belief that learners were taking "chances" at school because they knew that they could not be punished physically.

Researcher's comment: Researcher observed that both parties were unwilling to talk about respect and discipline. Both educator and learner respondents belong to a culture that the youngster must show respect for the adult at all times. Learners are very perceptive and know whether an educator can maintain discipline. An educator must have the three cornerstones of respectability well innate, namely: punctuality in the classroom, discipline and mastery of the subject. Learners will be punctual, attentive and cooperative, and performance will surface if the educator is managing the classroom effectively. Educators' expectation concerning discipline must be clear and must not alter from day to day. Learners need to know exactly where they stand on disciplinary matters.

- **Time management:**

The educator interviewees believed that learners lack time management: Educators showed a great concern when they were talking about time management from the learners' perspective. According to these respondents learners find it difficult to manage their time and subsequently not enough time is allocated to practise mathematics. Parents are used to giving the children chores to perform at home. The longer school hours introduced in 2000 aggravates the situation. Learners claimed that after school they usually have some errands to run before their parents arrive at home from work. One of them mentioned that he has to collect his little brother from school, go home and tidy the house. Afterwards he would rest and he only starts with his homework later. Researcher perceived that learner respondents were not happy with this situation at home, but they have no other choice.

Researcher's comment: From the responses obtained the researcher concluded that learners have limited time to deal with schoolwork at home. Parents give them duties to perform after school hours and learners feel that they are unable to expend enough time on their schoolwork. Due to limited time at home, learners do not know how to practise mathematics unless the educator gives them exercises to do. Time management is very important for learners to be academically successful. Learners must also revise exercises given, that is, must go over the lessons, which were given and practise other similar exercises. However with the limited time available learners are unable to do so.

QUESTION 3 – How do parents contribute towards bad performance of their children at school?

- **Unemployment:**

Responses given by the educators were focused on the creation of jobs, which would alleviate the problem unemployment among parents. Educators pointed out that some unions have taken progressive steps towards creation of jobs but parents are not trained for specific jobs. Great poverty exists. Learners were reluctant to belief answer the question posed to them. Based on their reluctance the researcher was of the opinion those learners did not comprehend the question and rephrased it. It was only then that one of the learners responded and said that the creation of jobs could remedy the problem. The other two learners were not able to answer the question. After the researcher explained and rephrased the question once more these two learners were not sure what the question meant and seemed embarrassed, because of their lack of understanding and not being able to cooperate. They did mention that their parents were not able to find jobs because they were uneducated.

Researcher's comment: Social problems like unemployment and lack of education among many of the parents will take years to remedy, but there is an urgent necessity to educate the parents. [Ever since a workshop in this respect was held in the school where this research was done, some improvements are visible]. Teaching strategies used by educators do not allow learners to develop the spatial sense and problem-solving skills. Visual education is often a neglected area in the curricula, although very essential because visualisation is the transfer of objects, concepts, phenomena and processes. This will help the learners to develop the ability to interpret, understand and create the mutual relationships.

QUESTION 4 – How best can all the stakeholders in education be involved in solving the problem?

From the responses obtained, all the stakeholders need to be involved in the following manner:

- **Parental involvement**

Educator respondents were of the opinion that too many black parents/guardians are still aloof from the system of teaching and learning. School management teams and school governing bodies need to have workshops with the parents/guardians and their children to make them aware of their responsibilities. The learner respondents focused on the fact that parents should be more involved in school affairs, but mentioned that their parents lack the time to become involved.

- **Adequate pre- and in-service training:**

The educator respondents stated that mathematics educators trained at disadvantage colleges should receive adequate pre-and in-service training. The learner respondents said they couldn't comment on pre-and in-service training. Researcher is of the opinion that learners did not have the knowledge to comment on this.

- **Improved attitude:**

The educator participants commented that educators and parents must work on learners' attitude towards mathematics from an early age in order to show the learners the relevance, importance and fun of mathematics. Learners highlighted that mathematics is not as difficult as everybody says. They add that learners need to believe in themselves and regularly practise the subject. They did not elaborate further on their answers.

- **Emphasis on lower grade work:**

All the stakeholders, in the opinion of the educator respondents, must regard all grade levels as important as Grade 12. Grade 12 educators should be required to deal with their part of the work only and thus leave ample time for learners to prepare for the examination. Learner interviewees felt that primary school mathematics educators need to be more creative and should try to make the subject attractive for all learners.

- **Language of learning:**

Educator respondents soundly believe that from primary school, educators should employ English as the language of learning in such a way, that learners will be able to grasp the meaning of all concepts. Provision should be made for opportunities for learners to interact and talk in the classroom. Two of the learner respondents mentioned that during their primary school years the educators did not use English as the language of instruction and learning in all the classes. They felt that all educators should be more sensitive towards the fact that they (the learners) are studying in a language which is not their mother tongue.

- **Problem solving skills:**

The educator respondents emphasised the importance of teaching problem solving skills and let learners find solutions for themselves. They were of the opinion that this approach will assist learners to study more effectively. The learner respondents all agreed that they needed to acquire problem-solving skills.

- **Relevant mathematics:**

Educator respondents commented that all mathematics educators must relate mathematics to the learners' everyday life. They said that this approach might help the learners to grasp concepts easier. A learner respondent said that examples from their life world would make understanding easier.

- **Sex stereotyping:**

In pre-primary school, educators should adapt the activities especially for girls, to also engage them in activities with the boys by playing with Lego, cars and others toys. Playing with these types of toys provides opportunities to develop the problem-solving and building skills inherent to success in natural sciences subjects. These were the words spoken by the educator interviewees.

From the above-mentioned responses it is apparent to the researcher that learner respondents struggled to elaborate on their answers. This may be because they did not understand some of the concepts, such as: pre-and in-service training, problem solving skills and sex stereotyping.

3.6 CONCLUSION

Education is facing new challenges. Educators are called upon to provide quality education to all learners and to prepare these learners to live and work in a world transformed not only by increasingly common demographic changes, but also by rapid growth in new technologies, international competitiveness and economic globalisation. Improving the science and mathematics achievement of all groups is important in meeting the challenges of the new century. A new South Africa should be built where no one is left behind. As the nation's economic base shifts increasingly towards technology, the participation and achievement of Blacks and women in the labour force are becoming increasingly important. South Africa can meet the projected shortage of scientists, mathematicians, engineers and technology professionals only by attracting underrepresented groups to these occupations. Unfortunately, underrepresented groups, on average, are the children most left behind in science and mathematics education.

Chapter 4 is devoted to PAR in order to design lesson plans that will assist educators to teach certain mathematical constructs and problems with more confidence. The lessons are based on cognitive development strategies of problem solving.

CHAPTER FOUR

PARTICIPATORY ACTION RESEARCH (PAR)

4.1 INTRODUCTION

Research is a systematic process of collecting and logically analysing information (data) for some purpose (McMillan & Schumacher 1993:8-9). The intention of this study is to find the factors that hinder academic achievement in mathematics at Grade 12 level and to suggest teaching strategies, which could improve performance in mathematics. Research methods, also called methodology, are the ways in which one collects and analyse the data. According to McMillan and Schumacher (1993:8-9) the choice of methodology depends to a large extent on the objectives of the learning unit, the content that is to be learned, resources available and the needs of the learners.

4.2 METHODOLOGY

PAR always implies some kind of improvement, development or change (Wickham 2000:3). The methodology adopted for this second part of the study was PAR because of the characteristics involved in it, as Kemmis and Wilkinson (1998:21-36) explains:

- First, PAR is a social activity in that it deliberately explores the relationship between the realms of the individual and of the society. It recognises that no individuation is possible without socialisation, and no socialisation is possible without individuation (Habermas 1992:26);
- PAR is also participatory in that it engages people in examining their knowledge (understandings, skills and values) and interpretative categories (the ways they interpret themselves and their action in the social and material world). It is also

participatory in the sense that people can only do action research on themselves – individually or collectively. It is not research done on others.

- PAR is collaborative in that action researchers aim to work together in reconstructing their social interactions by reconstructing the acts that constitute them. It is research done with others.
- PAR is emancipatory in that it aims to help people recover and unshackle themselves from the constraints of irrational, unproductive, unjust and unsatisfying social structures which limit their self-development and self-determination.
- PAR is critical in that it is a process in which people deliberately set out to contest and to reconstitute irrational, unproductive (or inefficient), unjust, and/or unsatisfying (alienating) ways of interpreting and describing their world (language/discourse), ways of working (work), and ways of relating to others (power).
- Finally, PAR is recursive (reflexive, dialectical) in that it aims to help people to investigate reality in order to change it, and to change reality in order to investigate it. It is a process of learning by doing – and learning with others by changing the ways they interact in a shared social world (Atweh & Heirdsfield 1998:3-4).

PAR in education is a powerful strategy for professional development. McNiff *et al.* (1996:7) assert that it can be used to improve professional practices. The researcher and the educators are observing the learners' behaviour according to the PAR programme. If learners are not reacting positively, researcher and educators will try another alternative to yield the positive response. In PAR, data is used primarily in two ways: to shape action and to monitor the effects (Wickham 2000:15).

4.3 RESEARCH DESIGN

PAR is the process of systematically evaluating the consequences of educational decisions and adjusting practice to maximise effectiveness. As McLean (1995:3-4) states, this involves educators and school administrators delineating their teaching and leadership strategies, identifying their potential outcomes, and observing whether these outcomes do indeed realise.

PAR is described as a family of research methodologies which pursue action (or change) and research (or understanding) at the same time (Dick 1999:1). In most of its forms it does this by:

- using a cyclic or spiral process which alternates between action and critical reflection; and
- in the later cycles, continuously refining methods, data and interpretation in the light of the understanding developed in the earlier cycles.

It is thus an emergent process, which takes shape as understanding increases; it is an iterative process, which converges towards a better understanding of what happens. In most of its forms it is also participative (among other reasons, change is usually easier to achieve when those affected by the change are involved), as well as qualitative in nature.

4.3.1 Cycles of PAR

This research was composed of two action cycles. The first cycle focused on analytical geometry of which the lesson plans and activities can be seen in Annexures A to F. This part of the syllabus, analytical geometry, provides the educator the opportunity to revise prior knowledge in Algebra. The second cycle focused on proportionality (Euclidean geometry). A lesson plan (p.50) and activities are given in figure 6 (p.52). This section of geometry furnishes the educator and learners with the opportunity to do diverse drawings to be able to understand the theorem and its application. The diagram below shows the principles in action, the movement from one critical phase to another, and the way in which progress may be made through the system.

Figure 1 – The principles in action (McNiff 1992:27). An adaptation.

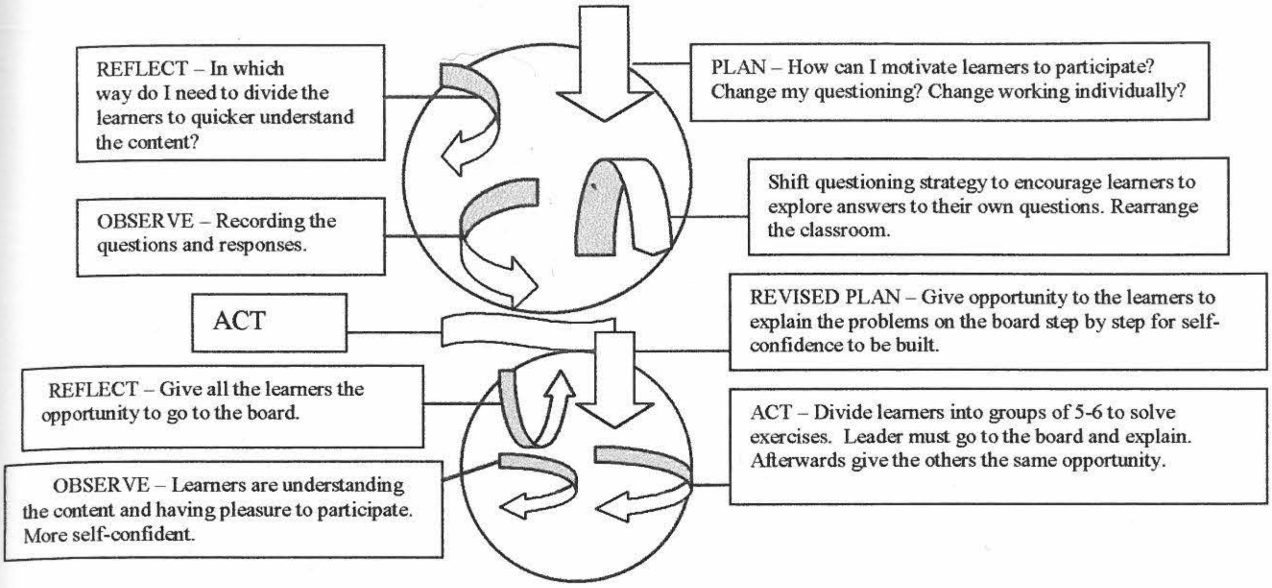


Figure 1 provides a guide for the reader to the aims, actions and strategies conducted during the first cycle – analytical geometry – and recalls knowledge already acquired in the previous years, such as:

- the midpoint of a line segment, where the axis of symmetry from algebra (re: parabola) can be recalled, which is halfway between zero points;
- gradient of a line, also given since Grade 9 when the straight lines graph was introduced. Followed by Grades 10 and 11 that requires more higher cognitive abilities like insight in the content. Even the circle and the parabola functions are given with the intersection of points to be calculated algebraically and with the aid of the graph, if done accurately. In trigonometry the angle which a line forms with the positive x-axis is given (inclination of a line or slope);
- the equation of a line (m: gradient and c: y-intercept) or the gradient (m) and the co-ordinates of one point on the line;
- perpendicular and parallel lines, can be the pre-knowledge of Grade 10;
- the equation of a circle with centre (0; 0) and a given point. This part of algebra was covered in Grades 10 and 11;
- points of intersection of lines and circles also covered in Grade 11 (algebra).

The first cycle, analytical geometry, contains very little new content. It can be dealt with easily if learners are used to working hard and systematically with the educator and others. Each cycle consisted of lessons as cycles within cycles, which were presented by the educators who kept diaries of experiences and observations.

In the second cycle, proportionality (euclidean geometry), the educator can help learners recall the following:

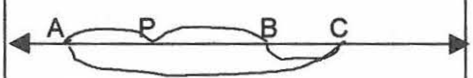
- the proportionality given in Grade 9, and
- the areas theorems given in Grade 10.

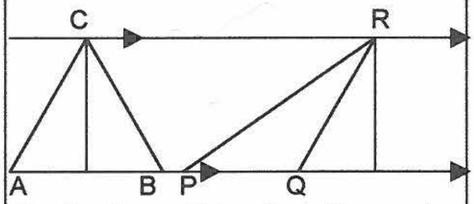
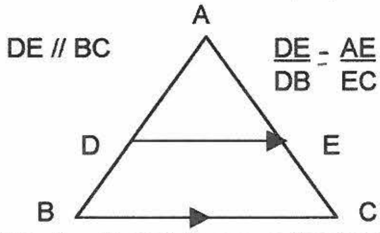
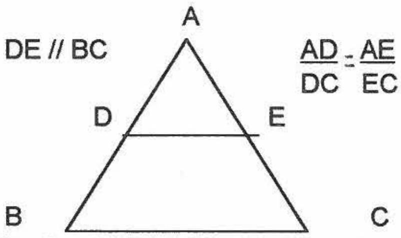
The plan of the implemented lesson follows and diagrams of some exercises are drawn to facilitate understanding for the learners. Learners were expected to study figure 6 (p.52) and relate that to the theorems.

EUCLIDEAN GEOMETRY

LESSON PLAN

Proportionality Grade 12 10.05.2000

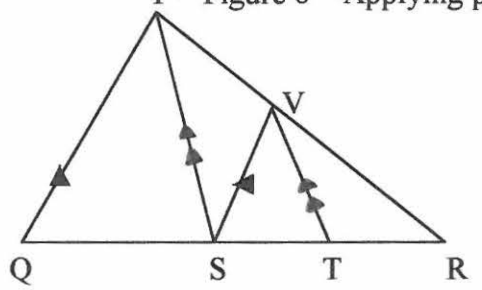
Lesson Phase	Time	TEACHER'S NOTES	Method	Teaching Aids
		Ratio and Proportion		
Actualisation of pre-knowledge	10 min.	In groups of 4/5 learners discuss what is meant by: * A point divides a line internally and externally.  Fig. 2 - Division of a line * A ratio is negative/positive. The groups give feedback after which the educator reinforces and/or corrects misconceptions.	Discussion	Chalkboard
		<u>INTRODUCTION</u>		
	10 min.	In their groups learners are guided to discover that: The areas of the triangles with equal altitudes are in the same ratio as are the lengths of their bases. That is, given 2 triangles with equal altitudes,	Discovery	

		learners determine the ratio of their areas, which should lead them to the conclusion above.  Fig. 3 - Area of triangles with equal altitudes	
Exposition of new content	20 min	The educator introduces the proportionality theorems and their proofs: 1. A line parallel to one side of a triangle cuts the other two so as to divide them in the same proportion.  Fig. 4 - Sketch to prove the theorem 2. If a line cuts two sides of a triangle so as to divide them in the same proportion, then that line is parallel to the third side.  Fig. 5 – Sketch to prove the converse Of the theorem An example to illustrate the application of each theorem is treated.	
Functionalization	20 min.	Class-work: Textbook: Classroom Mathematics, pg. 352-353 Exercise 10.1, 2 and 5. Corrections of class-work is done by the educator and problems identified are ironed out. Homework: Textbook: Study & Master pg. 261-262 Exercises 3, 5 and 7 This will be corrected by the learners	

		themselves, with explanations and reasons to their peers, the following day.	

The educator should ask the learners to take a ruler, a compass and six coloured pencils and play a discovery-with-figures game after the theorems have been explained. Study the following exercise. In the figure: PV = 24 cm; VR = 22 cm and ST = 12 cm. PQ // VS and PS // VT. Calculate: QR

Figure 6 – Applying proportionality



Learners must work with the figure according to the parallel lines; therefore they must redraw the figure, such as the following:

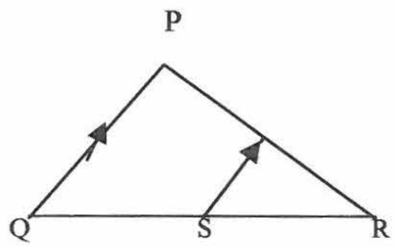


Fig. 7

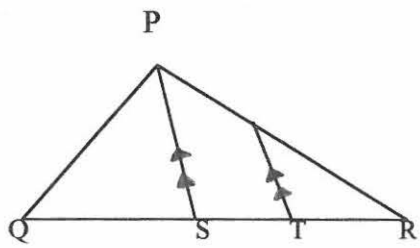


Fig. 8

In this way learners should be able to find the proportion required. Solution:

In fig. 8 Triangle PQR

$$\frac{TR}{ST} = \frac{VR}{PV} \quad (VT \,//\, PS)$$

$$\frac{TR}{12} = \frac{22}{24}$$

$$TR = 11 \text{ cm}$$

In fig. 7 Triangle PQR

$$\frac{SR}{QR} = \frac{VR}{PR} \quad (PQ \,//\, VS)$$

$$\frac{23}{QR} = \frac{22}{46}$$

$$QR = 48{,}1 \text{ cm}$$

A constructive, active view of the learning process must be reflected, in such way that much of mathematics is taught. Thus, instruction should vary and include opportunities for:

- appropriate project work;
- both group and individual assignments;
- discussion between educator and learners and among learners;
- practice on mathematical methods; and
- exposition by the educator (Suydam 1990:3).

No research can be done without site selection, participants, ethical considerations and data collection.

4.3.2 Site selection and participants

One public secondary school in the Thabong township of the Free State Goldfields was chosen, for PAR as cited in chapter one (cf. 1.6.1).

The researcher, two mathematics educators and two Grade 12 mathematics classes participated in the research. The researcher explained the motives for the research, which are to improve the Grade 12 pass rate in mathematics and all parties volunteered to assist.

The researcher worked with the educators in planning the lessons and when the action plan was implemented, the researcher acted as an observer-participant (cf. chapter one 1.6.3).

4.3.3 Cycles within cycles

The general nature of the PAR cycle is the essential features that are an alternation between action and critical reflection. The reflection in turn consists of a review of what has happened so far and deliberate planning for what will happen next (Dick 2000:1).

Before the programme began, the researcher and educators met to plan the action that they would take, and lesson plans were delineated. After the first two lessons were presented they met again to review the outcomes and to compare notes. After the first two lessons of the first cycle were concluded, the researcher and educators met for reflection and effected some modifications to the plan where it was necessary. Educators taught the learners while the researcher observed.

The first modification was made when the researcher and educators notice that learners were not as active as expected, which was probably the result of learners working individually. The researcher and educators then decided that the teaching strategy would be cooperative learning because small groups were involved and it would give learners the opportunity to discuss the exercises among themselves.

4.3.4 Cooperative learning strategy

Cooperative learning has been identified as one of the better approaches to mathematics education. Cooperative learning may be defined as a learner-centred instructional process in which small, intentionally selected groups of 3-5 learners work interdependently on a well-defined learning task. Individual learners are held accountable for their own performance and the educator serves as a facilitator/consultant in the group-learning process (Cuseo 1992:5-10).

Cooperative learning is a pedagogical technique involving learners' participation in small groups to accomplish shared learning goals and maximise their own and each other's learning (Lawrence & Foyle 1998:1). Johnson, Johnson and Smith (1998:1-2) state that educators should not see their learners as empty or passive vessels but as active constructors, discoverers and transformers of knowledge. Such educators would want to develop learners' talents and abilities so that they can function in real-world professional environments. Most importantly, these educators recognise that to do so, they must try to create learning situations that encourage learners to become actively involved. A metaanalysis of studies of small-groups (predominantly cooperative) learning in mathematics, science, engineering and technology disciplines, were conducted and the analysis showed that small group learning had a significant and positive effect on learners' achievement, persistence and attitudes (Johnson *et al*. 1998:2).

Certain procedures need to be followed when an educator wants to form a small group to foster true cooperative learning. The fact is, not every group situation facilitates true co-operative learning. The five basic elements of cooperative learning identified by Johnson *et al.* (1998:3) are the following, which differentiate true cooperative learning arrangements from other instructional small groups:

- positive interdependence;
- individual accountability;
- face-to-face promotive interaction;
- use of teamwork skills; and
- group processing.

4.4 IMPLEMENTATION OF PAR THROUGH COOPERATIVE RESEARCH

After the educators and the researcher that a cooperative learning strategy would be adopted took the decision, it was also decided that learners would work in groups of five or six to encourage learner participation. The educator and researcher chose a group leader and a reporter for each group. During the lesson presentation learners were encouraged by the educator to go to the chalkboard to do the exercises and, at the same time explain to the other learners what they were doing and why. Learners enjoyed working on the chalkboard because they could rely on the educators being there to help them out if necessary. Gender and ability were not considered, since everybody were given the same opportunity to work and learn. After the first day of grouping, the leaders and reporters were requested to rotate within the groups. Lawrence and Foyle (1998:1-2) stress that cooperative learning let learners feel successful at achieving tasks. Even low-achievers can make a contribution to the group experience and success, while all the learners increase their understanding of ideas by explaining it to other group members. Educators should test learner's pre-knowledge before new work is explained and if necessary, problematic exercises should be repeated by learners on the chalkboard in collaboration with the rest of the class. These exercises provide the opportunity for the educator to re-inforce mathematical vocabulary. The results of the group work were encouraging, because learners, even after class, re-grouped to do their homework and practice other exercises.

During the third lesson, learners were regrouped, but this time the better achievers were made leaders of the groups. This was intentionally done because the next lesson contained new content and at the same time the degree of difficulty was more elevated. At this stage the better achievers could support the weaker ones. The groups were working without difficulty and smoothly. For the fourth and fifth lessons the groups remained the same and it was observed that the pace of the lesson remained more or less the same as previously, even when they dealt with content that is considered to be more difficult to understand and assimilate.

The observation was made by the researcher and the educators that girls, as well as weaker learners started becoming more confident and willing to go to the chalkboard to explain the classwork and the homework. What has been observed and agreed upon is that the groups should not remain the same, they should be changed according to the content of the lessons or depending on what the educator has in mind to do in class. If groups remained the same for to long, then learners tend to start relying on the group leader and reporter, and there is no fruitful gain obtained from group work. The anxiety to perform the duties of a leader/reporter will vanish as learners realise cooperation is the keyword and not individual performance.

After the six lessons a test of which the learners were advised one week in advance, was given. The results were satisfactory and the weaker learners were performing much better than they did previously. The researcher and the educators concluded that, if learners are grouped according to the content of the lesson, learners work more consistently and faster than when they work individually.

Mathematics educators must be very patient during classes and should try not to laugh or criticise when a wrong answer is given. If this happens the learner will refrain to venture into new discoveries. The atmosphere in the classroom must be harmonious and with sufficient ventilation for learners to be able to think clearly and work properly.

4.5 CONCLUSION

In this chapter, qualitative research was implemented due to the fact that the intention was to investigate behaviour as it occurs naturally in non-contrived situations, and there was no manipulation of conditions or experience.

The research design adopted was PAR because it is a deliberate solution-oriented investigation that is group or personally owned and conducted. It is characterised by spiralling cycles of problem identification, systematic data collection, reflection, analysis, data-driven action taken, and finally, problem redefinition. The linking of the terms "action" and "research" highlights the essential features of this method: trying out ideas in practice as a means of increasing knowledge about and/or improving curriculum, teaching and learning (Johnson 1993:1).

Mathematics is often thought of as the discipline of "the right answer". Many educators are uncomfortable with this designation because it can interfere with their efforts to help learners express their mathematical thinking, to learn from mistakes, to experiment effectively and to pursue their mathematical interests (Lanius 2000:1). The research was based on two cycles and explained briefly with a sketch. Initially learners were working individually, but educators and the researcher concluded that working in groups provided the opportunity for the learners to communicate among themselves and brainstorm the exercises given. This elevated their self-confidence, which will be of benefit when the learners write their exams, participate in class and for their overall self-worth.

The research was done in one public school in the Thabong township in the Goldfields region, of the Free State province, involving two Grade 12 mathematics classes, two educators and the researcher. An exercise was exemplified with the respective figures for educators to follow if the research proves to be beneficial. Geometry was chosen for the lesson plans due to the fact that learners have difficulty in understanding geometrical figures. However, educators assisted them to determine the number of figures that they can take from a rider and recall the various theorems involved in it.

The ethical considerations involved were taken into account, such as: permission from the Department of Education to do the research, and approching the participants to participate in the study.

CHAPTER FIVE

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

5.1 INTRODUCTION

In this chapter, conclusions, relevant findings and recommendations are made, keeping in mind the fact that this research is based on a national crisis arising in South Africa.

The Senior Certificate examination at the end of Grade 12 is the only external scrutiny on performance in the South African school system, and the poor results since 1995, especially in six of the nine provinces, have bewildered the general public. The Minister of Education, Professor Kader Asmal (1999:5), states that the number of learners who study mathematics with any degree of understanding and proficiency has declined when it should have increased. Mathematical illiteracy is widespread in South African society, and the pool of newcomers for further and higher education in the information and science-based professions is deteriorating, a fact that has grave implications for the national future of South Africa in the 21st century (Asmal 1999:5).

New technologies have evolved, in part at least, from a mathematical view of the world. Certainly the application of mathematics in technological systems has been a generative process in creating new artefacts and contexts for new learning (Outcomes based education). Consequently, interest is growing in teaching approaches supporting conceptual understanding of mathematical ideas. In this approach to teaching mathematics, the teacher facilitates knowledge acquisition and orchestrates learning environments conducive to authentic learning of mathematical ideas (Manouchehri 1998:1). The above scenario sketches the need for research done in the area of mathematics achievement at school.

The following main questions were posed as research questions:

- What factors contribute towards the poor performance of Grade12 mathematics learners?
- What reasons are underlying the problem of the low pass rate of Grade 12 learners in mathematics?
- Can alternative cognitive development strategies be offered to remedy the problem?
- How best can all stakeholders in education be involved in solving the problem?

The aim of this research was to identify the causes/factors for poor performance of the Grade 12 learners taking mathematics as a subject and to investigate a teaching approach or delivery method to address the problem.

The above-mentioned problems, have been addressed in the study in the following way:

Chapter two comprises a relevant literature review where factors which can be the cause of the underachievement in mathematics has been identified according to literature sources. The negative image of mathematics was also explained. The deductive and inductive methods of teaching and eight approaches to mathematics teaching were also discussed. Finally, the importance of mathematics education for learners was emphasized.

The data collection and reporting on interviews compose chapter three, that is, questions were formulated, interviews were conducted and PAR was initiated. Responses were categorised and reported in a descriptive manner, while researcher's comments were added.

Chapter four utilises the PAR approach to determine which teaching strategies can be implemented to improve mathematics teaching in order to promote cognitive development and a better comprehension of the subject. A comprehensive explanation accompanied the implementation of PAR and the two cycles were duly exemplified.

5.2 LITERATURE FINDINGS

- Learners have difficulty in understanding mathematical language (cf. 2.5.1).

- Learners study in a language that is not their mother tongue, and as a result experience difficulty in understanding concepts in content subjects, such as mathematics (cf. 2.5.1).

- Teaching mathematics in impoverished areas complicates effective teaching and learning.

- Learners are in need of motivation towards the subject (cf. 2.5.3); there is, however, a stigma of difficulty attached to mathematics.

- Mathematics educators who obtained diplomas from disadvantaged colleges, are in desperate need of pre-and in-service training as they do not implement approaches such as problem solving and how to relate the content of the subject to real life, this renders the subject foreign to the learners (cf. 2.5.5).

- Cooperative learning can be a very useful approach in the teaching of mathematics. Such an approach allows learners the opportunity to discover, explain, summarize, and integrate the material to be learned into existing conceptual networks (cf. 2.7).

- The mathematics syllabi for Grade 8 to Grade 12 are too immense and congested to complete each year and therefore educators are unable to do remedial work due to the high learner-educator ratio in most classes. Many educators simply cannot complete each grade's syllabus to prepare learners sufficiently for the next grade.

5.3 FINDINGS FROM INTERVIEWS

After some reflection on interviews and responses obtained about reasons for the poor performance of Grade 12 mathematics learners, the researcher realized that there are factors occurring repeatedly and it concurs with literature findings, namely:

- Educators and learners in township schools are compelled to use their mother tongue in subject classrooms. English language was not mastered in primary school. Educators at secondary level struggle with learners in mathematics classes because of the language problem.

- "Good" educators are not allocated to lower grades (primary and secondary school); there is a desperate appeal for knowledgeable mathematics educators to teach at all grade levels.

- Many mathematics educators do not complete the full syllabus each year and therefore many learners suffer educationally due to a lack of pre-knowledge (cf. 38).

- Educators appeal for parent co-operation, support and motivation. Lack of social status conveys a wrong attitude from the parents, that is, negligence of their responsibilities (cf. 2.5.3).

- Unemployment of parents, which gives rise to poverty, is one of the reasons why learners cannot perform optimally.

- Learners acquire deficient knowledge of prior grade information. This originates from the fact that in the subsequent years, syllabi are not completed to sufficiently prepare learners for the next grade.

5.4 PAR FINDINGS

- After the first two lessons were concluded, the educators and researcher observed that learners were extremely passive. They noticed that if learners work individually they tend to be dormant and are slow to finish exercises. Consequently, educators, after completion of the second mathematics lesson, decided to implement cooperative learning. When learners were divided into groups, educators allocated position to them within the group, such as leader and reporter of the group. Learners became more active and willing to participate.

- During PAR it became evident that learners should rotate obligations to give everybody the opportunity to experience the responsibility of a leader/reporter.

- Learner participation (writing on the chalkboard) created enthusiasm for the subject.

- Learners with poor results became more involved and interested in mathematics lessons when working with small groups. They were given the chance to discuss their problems with others.

- Girls became involved in the discussion and were not inhibited by their peers. They became active participants in the class.

- Learners were happy to regroup after classes to solve more exercises and to do their homework.

5.5 RECOMMENDATIONS

- Children by nature are very creative; educators should continuously request them to associate what they are experience in class with real life world situations.

- Learners must use language, written and spoken, to express their thoughts and to demonstrate their understanding and mastery of academic tasks. That is, language is the vehicle of learning and instruction. English language represents a universe of language skills, and certain areas of language are used for specific purposes. Natural language, for example, the language used in everyday communication, is one of the components, or subsets, of this universe.

- Mathematics language (register) is difficult to understand. Educators must emphasise that success in reading and mathematics is based on process skills that incorporate the integration of contextual information and prior knowledge to produce meaning.

- In mathematics, numbers symbolize amounts, patterns or relationships. These words and numerical expressions create a basis for additional focus or information processing. Knowledge is communicated with others to share, compare and assess information. Moreover, reading provides both context and motivation for the mathematics learners.

- Schools should educate parents to create opportunities to work cooperatively with educators in enriching learners' experiences in mathematics.

- Mathematical concepts should be extended from the classroom to the home environment in an effort to establish the idea that mathematics is not just a school subject, but an everyday subject that makes life more interesting and understandable.

- It is essential that educators should receive good pre-service and in-service training. Educational authorities as a matter of priority should view this. Learning to teach is a lifelong process, of which pre-service preparation is just one phase. Ideally, educators should emerge from this phase as potential authorities in their own right, equipped with the skills and disposition to facilitate continuation of the learning process.

- In-service educational programmes should assist educators to become competent and should help some to attain the status of experts.

- Educators should make use of charts, posters and drawings done on the board with coloured chalk to simplify the subject. Asking questions during the lesson period alerts learners to be attentive.

- Learners' efforts should be acknowledged and praised for attempting or finalising an exercise. This will diminish the distorted image of the subject.

- Learners, who have the aptitude and ability, should be allowed to specialise in mathematics teaching at institutions of higher education.

- Instructional activities should serve as the means of connecting learners' informal, natural experiences with the formal aspects of mathematics. The assumption is that, learners will re-organise their informal quantitative and spatial schemata as a consequence of interacting in such activities. Schemata continually change as the individual grows and acquires additional experiences. Learners, who have developed an initial, but not well-organised schema, should be encouraged to search for further relevant information and experiences that will provide them with structure.

- Learners should be sufficiently motivated towards the subject mathematics. Motivation towards mathematics developed at an early stage, is highly stable over time, and is influenced greatly by educator actions and attitudes. Learners seem to consolidate their motivational attitudes towards mathematics in Senior Primary School, and these attitudes in the middle grades direct the individuals' choice of courses to be taken and their mathematics achievement in following years. These motivations are internalised into learners' self-concepts, thus affecting how they see themselves with regard to mathematics-related activities. Learners with high self-concepts related to mathematics tend to be more focused on the selection and use of specific strategies for successful problem solving, and are likely to pursue further study in mathematics.

- To continually keep learners active and motivated towards mathematics, educators must allow learners to go to the chalkboard to correct homework and classwork providing the necessary explanations.

- Time management should be taught to learners from Grade 1 onwards. Guidance classes must be introduced in primary schools to guide the learners through their studies effectively.

- In pre-primary school, educators must change the play and toys, especially for girls, allowing them to play with Lego blocks, cars and other toys, which will bring them in closer contact with the evolution of the world. Girls who are encouraged to play with these "boy" type of toys since their childhood is more likely to become involved in natural science subjects (cf. 2.5.2.1).

- Mathematics teaching should best be alternated with other subjects such as guidance to alleviate the mental fatigue. Natural science educators, especially in Grades 11 and 12, should not present too many periods in sequence because it may happen that they become mentally exhausted and not able to act creatively or think clearly.

- A strong need to raise standards of education for all young people is predominant in mathematics. As the reader can conclude from the responses given during the interviews, novice educators are in need of new methodology and new approaches to teaching.

- Parents, who are illiterate, poor and powerless, are unable to give practical and intellectual support to children. To remedy this, educational institutions must organise workshops for both parents and learners to attend so that those parents become aware of how to support their children. In one of the schools in Thabong the

School Management Developer (SMD) conducted a very successful workshop for Grade 12 learners and parents.

5.6 SUGGESTIONS FOR FURTHER RESEARCH

Suggestions for further research are discussed against the background of information collected from the literature study and data generated through interviews and written responses. Such suggestions comprise the following:

- Extensive research to improve mathematics results of learners in grades prior to Grade eight is proposed.

- Research is needed in primary schools to investigate the pass rate of Grade 7 learners in mathematics.

- Mathematics educators must do action research in their classes with the view to improve their teaching and learning methods.

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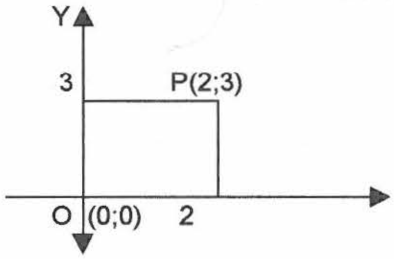
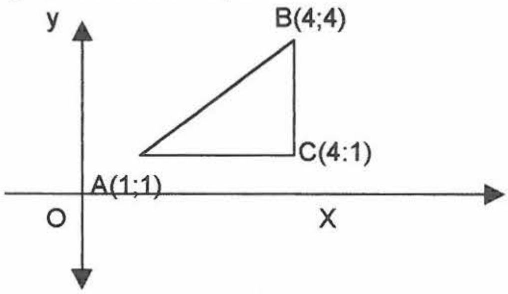
ANNEXURE A

ANALYTICAL GEOMETRY

LESSON PLAN 1

Date 27.03.2000 Grade 12

Introduction: a) Analytical geometry
b) Distance formula

Lesson Phase	Time	Teachers Notes	Method	Teaching Aids
Actualization of pre-knowledge	3 min.	What is analytical geometry? In analytical geometry we analyze a geometric figure in algebraic terms. The old name for analytical geometry is algebraic geometry. From the definition given, it is clear that in this part of mathematics we are going to calculate the length; perimeter etc. of different geometric figures (triangles; quadrilaterals, etc).	Lecturing	Chalkboard
	5 min.	Example 1 When we analyze the point P, we can see that from O, the origin, we must move 2 units horizontally and 3 units vertically. Hence the geometric point P is associated with algebraic pair of ordered pairs. Fig. 1 - Cartesian Plane with point P(2;3) 		
Statement of a problem	10 min.	Suppose the figure below was given and we were required to calculate the lengths of: (I) BC (ii) AC, and (iii) AB Fig. 2 - Given three points  Learners will be able to do (I) and (ii) easily. The last one (iii) - some would be able to do	Discovery	

		the problem (by making use of Pyth. Theor.). Learners' answers and solutions [expected solution]: (I) BC = 4 - 1 = 3 units (vertically) (ii) AC = 4 - 1 = 3 units (horizontally) (iii) AB = $\sqrt{3^2 + 3^2} = \sqrt{18}$ Units (Pyth. Theor.)		
Exposition of new content	10 min.	At this stage the educator introduces the new concept, that is, the distance formula by making use of Pythagoras Theorem. AB=$\sqrt{(4 - 1)^2 + (4 - 1)^2}$ OR $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ $= \sqrt{18}$ Learners are now told that every time they are required to calculate the distance between any two given points, the formula that they must use is $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ More examples were done. Classwork:		
Functionalization	10 min.	Textbook: Classroom Mathematics pg.117 Exc. 3.2 a,b,c Home-work. Textbook: Study and Master Mathematics (S.G.) pages 204 and 205 Corrections of classwork were done by the educator to clarify and ask questions if any. Home-work the following day must be done by the learners and explanations must be given when they are working on the board to internalize the content and be able to explain to the other learners. Learners were working individually.		

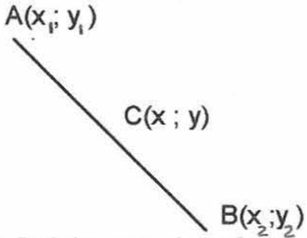
ANNEXURE B

ANALYTICAL GEOMETRY

LESSON PLAN 2

Date 28.03.2000 Grade 12

Determining equation of a straight line

Lesson Phase	Time	Teachers Notes	Method	Teaching Aids
	20 min.	Correction of the home-work given is done by the educator. Time given for questions.		
Actualization of pre-knowledge	5 min.	Determining the equation of a straight line from the given information Fig. 1 - Given three points  To find the equation of a straight line through $A(x_1; y_1)$ and $B(x_2; y_2)$, we let $C(x;y)$ be another point on the line and use the fact that $m_{AC} = m_{AB}$ Therefore $\dfrac{y - y_1}{x - x_1} = \dfrac{y_2 - y_1}{x_2 - x_1}$ $y - y_1 = \dfrac{y_2 - y_1}{x_2 - x_1}(x - x_1)$ Straight line formula will be: $y - y_1 = m(x - x_1)$	Lecturing	Chalkboard
Functionalization	15 min.	Some exercises to apply the formula given. Determine the equation of the line through: a) (1;2) and (-1;3) b) (-1;-2) with slope of 3 c) (-2;5) and parallel to 2x - 3y =12 d) (-1;3) with inclination of 45 e) (3;-4) and perpendicular to 2x - y = 4. Learners were working individually. Exercises were explained on the board by learners. Home-work given on the two lessons.		

ANNEXURE C

ANALYTICAL GEOMETRY

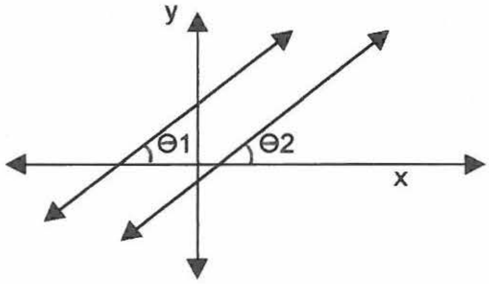
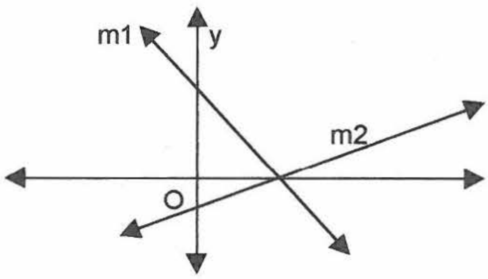
LESSON PLAN 3

Date 29.03.2000

Grade 12

a) Parallel lines
b) Perpendicular lines
c) Colinear points

Lesson Phase	Time	Teachers Notes	Method	Teaching Aids
Actualization of pre-knowledge	5 min.	Learners are reminded of the work done in grade 11 on straight line graph. In the equation y = mx + c, m is the gradient/slope. Then gradient is $m = \frac{y_2 - y_1}{x_2 - x_1}$ That is $m = \frac{\text{change in y}}{\text{change in x}}$	Lecturing	Poster and Chalkboard
		Determine the gradient of the line that joins the point A(2;-5) and B(4;9) Solution: $m_{AB} = \frac{-5-9}{2-4} = \frac{-14}{-2} = 7$		Chalkboard
Statement of the problem	10 min.	Learners' attention was drawn to these: May you please explain tan ϴ in terms of x and y. Answer: tan ϴ = x/y. Is there any relation-Ship between tan ϴ and the gradient? From the definition given, the two are the same, i.e. Tan ϴ = m Exercise: Calculate the angle which the line passing through (-2;-2) and (3;4) makes with the positive x-axis. Solution: $m = \tan \Theta = \frac{4+2}{3+2}$ $\tan \Theta = \frac{6}{5}$ $\Theta = 50{,}2^\circ$ Another example: Calculate the angle which the line passing through (-3;5) and (2;0)	Discussion	
Functionalization	15 min.	Classwork was given but this time learners will go to work into groups of 5 learners, where	Co-operative	

		one learner is the leader of the group and other will be the reporter of the group and must go to the board and do the correction with explanation of it to the class.	learning	
	3 min.	1) Parallel line Fig. 2 - Given two parallel lines  What conclusion can we draw about the gradient of the parallel lines Conclusion: m1 = m2	Lecturing	Chalkboard
	4 min.	2) Perpendicular lines: m1 x m2 = -1 Fig. 2 - Given perpendicular lines  	Lecturing	Poster and Chalkboard
	2 min.	3) Collinear points - are points that form a straight line and their gradients are equal m1 = m2 = m3		
Functionalization	15 min.	Classwork: Textbook Classroom Mathematics page 126 Exercise 3.4 no. 8, a; b and c.	Co-operative learning	

ANNEXURE D

ANALYTICAL GEOMETRY

LESSON PLAN 4

Date: 30.03.2000

Grade 12

a) Mid-point

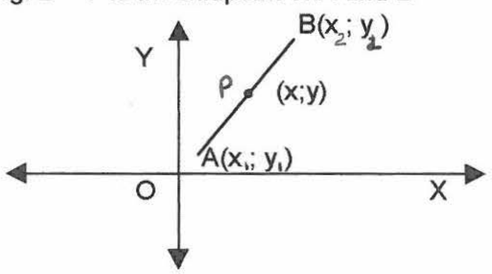
Lesson Phase	Time	Teachers Notes	Method	Teaching Aids
	15 m	Homework is marked. Learners were given time to ask questions about the work done so far.		
Actualization of pre-knowledge	2 m	What is the midpoint of a line segment? In trying to answer the question, let us draw a number line. Fig. 1 - Number line 	Discovery	Blackboard
Statement of a problem	5 m	Suppose we were required to find the mid-point between 2 and 6. By looking at the number line the answer is 4. But how can we conclude that? If you add 2 and 6 and divide by 2 the answer is 4. Let us see another example. What will be the midpoint between 2 and 4 but making use of the number line? That will be 3. The formula used is it valid? Can we use the formula everytime we are required to find the midpoint?	Questioning	
Exposition of new content	5 m	Fig. 2 - P is the midpoint of A and B  Exercise - Find the co-ordinates of point P in		

		fig. 2, the midpoint of AB. Learner will be able to answer the problem. P (x;y) = $\frac{x_1 + x_2}{2} = \frac{y_1 + y_2}{2}$ Then this will be the formula that you need to use to find the midpoint co-ordinates. Determine the co-ordinates of P, the midpoint of AB, if A(2;-4) and B(4;2). Solution: $P\left(\frac{x_1 + x_2}{2} = \frac{y_1 + y_2}{2}\right)$ $P = \left(\frac{2 + 4}{2} = \frac{-4 + 2}{2}\right)$ P = (3 ; -1) Time were given to the learners to ask any question about midpoint formula and deduction of it. Educator grouped the learners but this time the best ones were the leaders of the groups to do the classwork.	Co-operative learning	
Functionalization	20 m	Classwork - Classroom Mathematics p.121 exercise 3.3 no. 1 from *a* to *f*. Home work: Classroom Mathematics p. 121 exercise 3.3 no. 2 and no. 3.		

ANNEXURE E

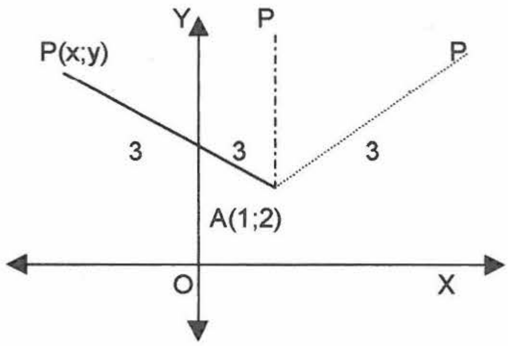
ANALYTICAL GEOMETRY

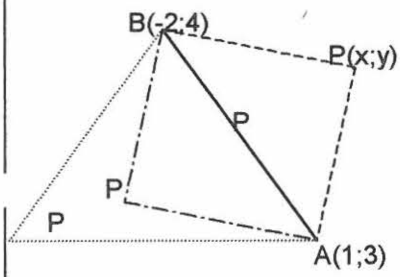
LESSON PLAN 5

Date: 04.04.2000

Grade 12

a) Locus

Lesson Phase	Time	Teachers Notes	Method	Teaching Aids
Actualization of pre-knowledge	5 min.	What is the locus of a point? If learners are taken Technical Drawing as a subject the eduacator can remind them when they gave locus and what they can say about it. If not give them the answer but with a poster be done about locus. Answer: A locus of a point P is a set of all points which P can assume when it has to satisfy certain conditions. Example: Determine the locus of a point which will remain 3 units from point (1 ; 2). Fig. 1 - Locus of a point  When dealing with the locus of a point you must keep in mind the following steps which are very useful to answer the questions: 1) What is the condition here. 2) Draw a sketch representing the information 3) Write this in the form of an equation, such as; known points (x;y) -- moving points (x;y). 4) Simplify. Solution: Let P be (x;y) and the point with coordinates (1;2) be A. condition: $AP = 3$ $AP^2 = 9$	Lecturing	Poster and Chalkboard

		$(x - 1)^2 + (y - 2)^2 = 9$ Solve the equation $x^2 -2x +1 + y^2 - 4y + 4 = 9$ Simplify $x^2 - 2x + y^2 -4y = 4$ is the required locus.		
	5 min.	Example: Determine the locus of a point P which will always remain equidistant from A(1;-3) and B(-2; 4). Fig. 2 - The points P can assume  Solution: Let P(x;y) condition AP = PB square both sides of the equation $AP^2 = PB^2$ $(x-1)^2 + (y+3)^2 = (x+2)^2 + (y-4)^2$ $x^2 -2x +1 +y^2 +6y +9=x^2+4x+4+y^2-8y+16$ $14y = 6x +10$ simplify $7y - 3x = 5$		
	10 min.	More examples were given with the educator explaining each example throughly because pre-knowledge about the content is very few and the more different examples with sketchs given the better the learner will understand and at the same time visualise and ask questions to be able to consolidate the new content.		
	15 min.	Classwork: Groups will remain the same as previous day with stronger learners as leaders of each group. Classroom Mathematics p. 148, exercise 4.3 no. 3,4,5,6. If learners were not able to finalise the exercises in class they must finalise them as a homework.	Co-operative learning	

ANNEXURE F

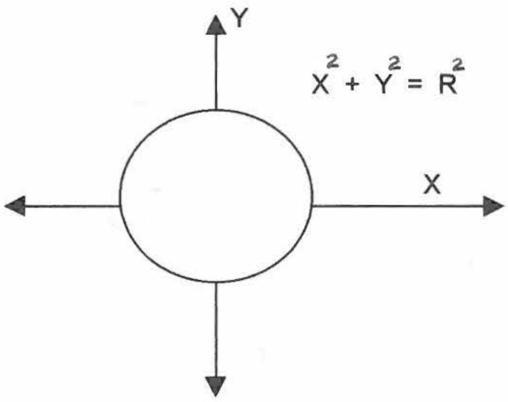
ANALYTICAL GEOMETRY

Grade 12

Date: 06.04.2000

LESSON PLAN 6

a) Equation of a circle

Lesson Phase	Time	Teachers Notes	Method	Teaching Aids
Actualization of pre-knowledge	2m	Learners are reminded of the equation of the circle with centre (0;0) and radius r, given in algebra, in Grade 10 and 11. They are told that r is the distance from centre to any point on the circumference. Equation: $x^2 + y^2 = r^2$ Fig. 1 - Circle with r (0;0) 	Lecturing	Poster and Chalkboard
Statement of the problem	10 m	Suppose you are required to calculate the equation of a circle at origin through point (a;b) Answer: $x^2 + y^2 = a^2 + b^2$ (see Classroom Mathematics p.150) Now using the answer above determine the equation of the circle with centre at origin through points: a) (4;0) b) (-5;12) Answer: a) $x^2 + y^2 = (4)^2 + (0)^2$ $x^2 + y^2 = 16$ b) $x^2 + y^2 = (-5)^2 + (12)^2$	Questioning	

		$x^2 + y^2 = 25 + 144$ $x^2 + y^2 = 169$		
	10 m	More examples were given with the educator helping the learners to get the correct answers individualy.		
Functionalization	12 m	Classwork is given: Classroom Mathematics p. 151, exercise 4.4 nos. 5,6,7 and 8. Learners were divided into groups, but this time no preferences were taken into account. After classwork were correct and explained by the learners on the board, homework was given, to be correct the following day.	Co-operative learning	Chalkboard