

Trends in Participation, Performance and Career Choice, among Girls who are Successful in Mathematics.

By

Regina Miriam Essack

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Faculty of Humanities,

School of Educational Studies,

University of Durban – Westville (UDW),

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Supervisor: Dr. Renuka Vithal

Dedication

To my husband, Omar. I love you.

My girls, Hannah and Thembi.

Acknowledgements

My Dad. I love you.

To all the girls involved in the study. You have always exceeded what I expect from you. Thank for the rich material that you provided for this study and your kind permission to allow it to be published.

Dr. Renuka Vithal – I learned much from your drive, determination and passion for research.

Krishni and Juggie Perumal – for all the assistance, guidance and ideas.

Veron and Trevor Naidoo – for feeding my brain and support.

My principal, friends at school, parents of the governing body, for always being available to assist.

Abstract

The question that this study attempts to answer is ‘**why do females who usually perform well in mathematics, not choose to study it further?**’

I will attempt to examine this question on multiple levels:

First, an examination of the statistical trends in **participation and performance in mathematics, by gender**

- for the **matriculation** examination in higher-grade mathematics, **nationally and provincially**.
- at Ridgepark College, an all-girls **school**, where a significant part of this study is based.
- at the **Universities** of Durban –Westville (UDW), Natal-Durban (UND), South Africa (UNISA).

Second, and against this statistical portrait, a **categorised examination** of a group of twenty **female learners** relating to their mathematical lives and their mathematical choices follows. Third, and from among this group, the **narratives of five female learners and myself** (I have included my experiences as part of the data) follow, intending to deepen understanding about how patterns come to be produced, and to catalyse the interrogation of issues that arise from these narratives.

“Nelson Mandela defeated apartheid in South Africa, and won a victory for all mankind. But he knew that it would not be enough to defeat the evil of discrimination. He knew that something new had to be created as well, a political, social and economic order in which all Africans, regardless of race, could prosper and contribute to the future of their nation. The principles and values at the heart of his struggle are universal: human rights, co-existence, democracy and development”, Kofi Annan, Secretary General of the United Nations (2000). It is these principles and values that have initiated, informed and underpin this study. In the context of a democratic South Africa, where a strong culture of redress and affirmation of females exists, it remains a curiosity that the mathematical field, academic or job related is not representative.

My study attempts as its core, an exploration of female mathematical lives, a documenting of our formative mathematical experiences in teaching and learning, an analysis of our choices and what informed these, which were then transposed onto the wider statistical landscape of South African mathematics trends in participation and performance, that had been set up in the prior chapter. While lives are a complex and intriguing tapestry, I hope that I was able, to capture and convey the vibrancy and colour that has emblazoned my newly discovered mathematical landscape. The methodologies used, pertaining to the group include: autobiographical writing, interviews and questionnaires. All data in the study was subjected to comment and analysis.

I have found that we are all moulded by our experiences with our families, friends, schooling, and society. We develop a social identity through a social context. It is within these and from these parameters that we exercise our choice. Transformation in South Africa tests the individual to make sense of competing forces towards the

establishment of a new identity. This study keeps as its focus, the limited extent to which females, in particular, choose to develop their mathematical identities. If they are indeed participating in mathematics, how are they performing and what contributes to their performance and the choices that they exercise in mathematics? The conclusions derived from my rigorous study were by no means simplistic, but must be seen as the competing integration of, at times attractive and cohesive social, political and economic forces which would just as quickly evolve to be disparate and in-cohesive, making the sense-making of this exercise all the more challenging, creative and exciting.

The Group of Girls who Participated in the Study



Picture: September 2001

Published with the kind permission of all participants. Certain girls who submitted their autobiographies, were absent when this photograph was taken

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Chapter One - Introduction

Everywhere our knowledge is incomplete and problems are waiting to be solved. We address the void in our knowledge, and those unresolved problems, by asking relevant questions and seeking answers to them.

The role of research is to provide a method for obtaining those answers by inquiringly studying the facts.

LEEDY, 1991

1.1 An Overview

Like music, mathematics has the power to transcend cultural, political and social barriers. Fermat's last theorem can be worked on by mathematicians Srinivasa Ramanujan, a rural tailor's son, in India, move to Andrew Wiles, at elite and prestigious universities in the United Kingdom and progress can cross the oceans, to be understood in Japan. Mathematics can transcend age and time, can extend invitations to all peoples, everywhere, to participate and enjoy as the challenge in the article, that follows on page 2, shows. The last century even saw the efforts of women acknowledged. Yes, my introduction does imply equal access to the boundaries, confines and pleasures that we in mathematics are already privy to.

by the way

To get the world thinking

IF SQUARE root signs and algebraic theorems never looked appealing before, consider this: A group of the world's top mathematicians is offering \$7 million (R50 million) for solutions to some of the world's hardest equations.

After puzzling for years over a set of seven unsolved maths problems, a US-based mathematics foundation has put the challenge, dubbed the "Millennium Prize Problems", to the rest of the world. Mathematicians say solving the problems, one of which has stumped even the best of them for well over a century, could lead to breakthroughs in encryption and aerospace and open areas of mathematics not yet imagined.

The Clay Mathematics Institute, which includes the world's premier maths minds as members, posted the problems on its website at the same time it unveiled the contest in Paris at its annual meeting.

"The seven mathematical problems stand out as great unresolved problems of the 20th century," said Andrew Wiles, a Princeton maths professor known for cracking a 350-year-old conjecture known as "Fermat's Last Theorem" in 1995.

The group has posted a price tag of \$1 million (R7 million) on each of the seven problems. Few expect that winners will emerge anytime soon.

"There's no time limit," said Harvard maths professor and president of the Clay institute Arthur Jaffe. He guessed that awards would come no sooner than four years from now. - Sapa-AP

MERCURY 25-05-00

Yet as many-a-Hollywood movie warns, '*all is not as it seems*'. While it may be able to cross borders and languages, social, economic and political strata, the one thing that becomes very apparent is that not all people are equal before mathematics.

Education officials express their concerns over the number of students that attain Matriculation Higher Grade passes in mathematics every year. In addition, they

worry that the low number of black¹ students who obtain higher grade passes in mathematics, will severely hamper efforts to improve racial diversity within mathematics and science-based professions, such as accounting and engineering (Khan, 2001). Such was commentary on the most recent matriculation examination, 2001, and are a constant refrain since our first democratic election. As teachers of mathematics, we deliver a standardised syllabus, as a province we offer opportunity for teachers of mathematics to upgrade their mathematics qualifications (CASME²-University of Natal), professional organizations make mathematics-support frequent and accessible to all teachers involved with matriculation mathematics classes (AMESA³), resources have been redirected to disadvantaged schools...why are we not then able, to celebrate mathematics results? And in particular, where do these disparities originate?

My philosophy as a teacher of mathematics is that all students can learn mathematics. I am based in an all-girls school where this study was conducted. It gives specific attention to understanding how females learn and experience mathematics, how they participate and perform in mathematics, and, when and where they choose to opt out of mathematics. South African society, with its labour and employment policies reflecting the priorities of affirmation and redress, in particular, needs to close the achievement gaps and to address the absence of females in mathematics related fields (Department of Education, 2000b). This chapter will expand on the questions that this study deems critical to addressing these concerns.

1.2 Background, Focus, Rationale and Research Questions

This chapter examines the origins of the study, and sets the scene for the questions that unfold and deserve answer. Further, it will define terminology that is used and place the study within the context of policy frameworks. At the outset, we must accept, that within education practice in general and mathematics teaching and learning, in particular, many forces serve to challenge and constantly refine and

¹ Black students in this study refers to all students that are not white i.e. African, Coloured and Indian.

² CASME is the Centre for the Advancement of Mathematics and Science Education.

³ AMESA is the Association of Mathematics Educators of South Africa.

redefine boundaries. This study was an endeavour that I hoped, would positively impact on my practice.

1.2.1 Background of the Study

This is a study in the main, of my own class at Ridgepark College. I have accumulated well over a decade of experience as a teacher in mathematics. The significant part of which, has involved the teaching of Grade 12, matriculation learners, on the higher or standard grades. Three years ago, a transfer to an all-girls school, Ridgepark College, provided the impetus for the direction of this study. Having previously taught at co-educational schools, the move prompted the inevitable comparisons. At co-educational schools, it seemed girls tended to work harder than the boys, preferred structure in their teaching and learning more, were better organised in terms of their work assignments, and appeared to assign far too much importance to what the boys thought of them. Now, with the absence of boys, all of the above still persisted, except, in addition, I also came to notice, that girls were limiting themselves in terms of their career and study choices. They seldom chose mathematics or mathematics related study paths and consequently, careers. These, often more higher paying and prestigious jobs (teaching being the exception), were left in the hands of males. Mathematics or mathematics related paths, this study defines as the likes of academic, teacher, engineer, astronomer, statistician, physicist, actuary or any career path that required the study of mathematics at university level as a choice and where a level of mathematics competence, above that of school, is required for the job that is chosen. In addition, it appeared over the years, as an idle curiosity at first, that girls who were very successful in mathematics at school: passing consistently well, above 60% on school based assessments on the higher grade, with eventual matriculation mathematics symbols of a 'C' or above, did not regard further study of mathematics or mathematics related careers, as defined above, as options. This incongruity served to become a focus of this study.

Ridgepark College is a school, which, in current South African terms, would be called 'advantaged'. It is a school that is well resourced, provides excellent facilities to its learners, and produces excellent matriculation results. It inculcates a very strong work ethic among learners and the staff are all fully qualified in their teaching areas.

All teaching and learning are geared towards the maintaining of an enviable matriculation pass rate. The school holds a population of approximately 1100 female learners. In the last four years, while I have been there, the majority of the learners, in excess of seventy percent, have been African. Due to the excellent results that it produces and a comparatively (to other ex-Model C schools in the area) cheaper fee structure, it frequently has to turn away girls once the quota has been reached. Further, in addition to the standard curriculum offerings, all girls leave the school certified computer literate, participate in a work experience programme in their area or field of interest, receive extensive guidance and counselling, where apart from a full-time counsellor, outside agencies with specialised information are called in to assist.

Pertaining to mathematics, girls are encouraged to participate in most external competitions and Olympiads. The mathematics department is supported by the governing body and are funded to attend conferences and workshops that are held by professional and academic bodies throughout the year. The parent body and governing body place strong emphasis and value highly, success in mathematics, they readily assist with the purchase of support materials that teachers and learners may require. Regarding the curriculum, the school offers a wide variety of subject packages for learners to choose from at the start of grade 10. Approximately 20% of the packages do not contain mathematics. These are designed so that learners that are not coping in mathematics are given the best chance to still obtain a matriculation exemption. Generally Fridays, 13h30 till 14h30, is an hour reserved where successful learners in mathematics 'BUDDY' those that may not have passed a test that week or are experiencing difficulty with concepts. A mathematics teacher, who assigns these BUDDY-tutors, who are usually high achieving grade 11's and 12's, supervises the hour. The idea is for learners to teach and learn from each other. It is my observation that the girls benefit substantially from this co-operative environment and tend to show significant improvement in subsequent assessments. These observations also affirm researchers, such as Boaler (1997), who focus on the environment under which girls work best.

1.2.2 The Focus of the Study and the Research Questions

From the above, one easily gets the impression of the importance and value with which the school regards mathematics, with numerous efforts geared towards the success of our learners. All efforts are directed towards the increased participation of girls in mathematics and contingencies are in place, to enable and enhance their improvement and performance. Their career paths and study direction, post matriculation, are also assisted with work experience programmes at companies and presentations from tertiary education institutions eager to recruit new students the following year. The questions therefore that arose and are critical to this study are:

Why are girls, who are successful in mathematics (as defined by this study), not choosing to study mathematics further at university?

Why are girls, who are successful in mathematics, not choosing careers that rely on specialised mathematics competence, beyond that acquired at secondary school?

These questions begged an examination of:

How are girls, as a collective, participating and performing in mathematics at matriculation level, nationally?

How are girls, as a collective, participating and performing in mathematics at university level?

The above questions prepare the background canvas of this study, the broader strokes, onto which the participation, performance and choices of a group of girls, at Ridgepark College are imposed. In particular, this study examines closely, successful girls (as defined above), on the Higher Grade in mathematics, who it is reasoned should be more inclined to choose mathematics at tertiary level or a mathematics related career. So, imposed on the broader picture, this study further examines, **how the girls at Ridgepark College, a subgroup of the larger collective (girls in matric mathematics nationally, and in university mathematics courses) participate, perform and choose in mathematics?** They have provided the finer detail.

The attempt to answer the above questions focuses on what statistical data exists, that reflects female participation and performance trends in mathematics at school and universities. This gives us the opportunity to gauge the broad trends of how females, as a group, generally, are participating, performing and choosing in mathematics.

Alongside this we examine as categorised, the mathematical life histories of twenty, grade 12, higher grade mathematics females. We ask, what career/study choices they were making and the reasons that their choices include or exclude mathematics. In addition, I present the detailed narratives of 6 females, who are successful in mathematics, myself included, with a view to obtaining an understanding, of how females are operating around their mathematical choices, considering the various forces that impact on the decisions that they make. Variables relating to society, culture, teachers, classroom organization, expectations for the future, home support, were identified and their effect on female choice in mathematics was examined.

1.2.3 Rationale for the Study

The issue of mathematics participation and achievement for females is a national and international concern (Department of Education, 2000c). It troubles me, as an educator and researcher, that in mathematics, there is an apparent lack of achievement by girls and further a lack of girls in mathematics careers that require sophisticated mathematical knowledge (Seliktar, 1998). The statistics acquired and used in Chapter 4 of this study, show that females appear to take fewer and less advanced courses in mathematics, often using these opportunistically to gain entry into other fields. Efforts to close the gap have to be intensified. To reiterate the words of Kofi Annan, *"South Africa needs all Africans to prosper and contribute to the future of the nation"*. We have a moral commitment, to redress, to provide equal access and equal education to both sexes. I am of the opinion that the imbalances of the apartheid legacy, are least well served by political rhetoric and idealism but by concrete and pragmatic measures, that address the needs of the peoples most disadvantaged, our African⁴ female learners. *"High School pupils who drop out of Maths and Science are in danger of closing the doors of economic empowerment"*, Seiler (2001). On the first level, we have to raise the participation and performance of historically disadvantaged learners, of which females form the largest quota. On the second level, it is an economic imperative to increase the size and face of our mathematically and technologically skilled work force and to provide females with an education required for financial self-sufficiency. On the more pragmatic level, we as teachers in

⁴ African in this study refers to the peoples that are indigenous to Africa.

mathematics need to critically examine, the nature of mathematics education in South Africa and the way that it works to exclude female involvement. To interrogate, the way that mathematics treats females, with a view to increase interest and achievement in mathematics.

One has to admit, that generally, the expectations of females, if not by themselves then certainly by others, with regards to mathematics are lower (Leder, 1996). Even if attempts are made to suitably empower females, their parents and teachers have been products of these debilitating socialisation patterns, which have to manifest in behaviour in some form. Sex stereotyped roles are often accepted and practised unconsciously. Simply, as teachers or parents, we have to admit that we treat females differently, and mathematics in particular, comes, with well-established socialisation patterns. This must impact on the way that girls learn and view mathematics. To illustrate, an analysis by Hanna, Kundiger, and Larouche (1990) of mathematical achievement by grade twelve girls in 15 countries -all but three, Thailand, British Columbia, and England- showed girls were less successful than boys. These findings reflect the sex - stereotyped perceptions that girls can't do mathematics.

The mathematics at Ridgepark College exists within this interesting dichotomy, that of mathematics being made more accessible to its female learners (the efforts are listed above) and then, the societal stereotypes that cumulatively effect an inaccessibility. The school's efforts to counteract negative social stereotypes and encourage the participation and assist the performance of it's female mathematics learners can only have its effectiveness measured by how it's females are performing compared nationally and the mathematical choices that the females make post-matriculation. From these choices, for which the girls in this study have provided detailed explanation, we should be able to deduce, if mathematics at school was a choice that they felt they had to, or wanted to engage in, and whether they would choose, to prolong the engagement, when they were given the freedom to choose mathematics, at tertiary level.

1.3 Relationship of Practice and Policy

A challenge that this study constantly faced was the acknowledgement that the questions that it sought to answer were impacted by multiple variables; that a straight forward linear solution or understanding was best suited to Linear Algebra and would provide a very incomplete and illusory explanation for the answers sought; that people were complex and not easily categorised to expedite an understanding or answer. A sphere of influence around each individual ensures that decisions and choices are made in particular ways. What are these variables that control and influence the sphere that surrounds females in mathematics? That impact on the way that females participate, perform and exercise choice in mathematics? As an initial point of departure, I sought the direction that policy gives mathematics teaching and learning in general, and its emphasis on females in particular. We see in most recent policy and mathematics directives, below, the emphasis to improve female participation and performance. All schools, mathematics teaching and learning, it is intended, will be guided by these statements.

1.3.1 Mathematics Education Policy

Here I present a selection of policy and guidelines. It would be cogent to elaborate the mathematics department policy at Ridgepark College as it informs the site at which this study is based. I call this the micro-level as it informs /directs the philosophy and culture of the mathematics classroom at Ridgepark specifically. On the macro level, I will expound the varied departmental policies that show gender sensitivity to mathematics teaching and learning.

1.3.1.1 The Micro-Level of Policy- Ridgepark College

The **Mathematics Subject Policy of Ridge Park College (2001)**, which this study views as having it's place at micro level when compared to the policies under which schools in general fall, has as its broad aims , that mathematics teaching will:

"First, enable learners to gain mathematics knowledge and proficiency.

Second, develop clarity of thought, accuracy and ability to analyse and make logical decisions.

Third, encourage learners to see relationships, estimate the plausibility of deductions and use this ability in daily life.

Fourth, foster good habits regarding systematic, accurate, neat working methods.

Fifth, encourage in pupils the desire for an interest in further study in Mathematics and Science fields.”

It is my candid assessment, at this point, that we, as a school, are succeeding on the first four aims and in addition, are working on the assumption, that the fifth aim will automatically be met.

1.3.1.2 The Macro-Level of Policy- National Education

It would be appropriate at this point, to expand on the macro context of mathematics education: the first democratic administration, of South African education, saw the establishment of the provincial departments of education through consolidation into unitary organization that sometimes combined up to 8 ethnically defined pieces. Racial legislation was repealed and replaced, provincial examination systems were set up, the NQF⁵ was formed and a new curriculum introduced. Even, the **Qualifications Framework** recognises in its objectives, mathematics as an area where there is a skills shortage and where South Africa lags behind other countries at a comparative level of development (Department of Education, 2000b). It also recognises that, mathematics is often a pre-requisite for other qualifications. In addition, an examination of national policy below- at a macro level, reads with the strong emphasis on addressing gender imbalances, as well as the need for a scientific and mathematically literate workforce.

The Thrusts of the National Strategy for Mathematics, Science and Technology are: *“to raise participation and performance by historically disadvantaged learners in Senior Certificate mathematics and physical science; to provide high-quality mathematics, science and technology for all learners in the General Education and Training Certificate and the Further Education and Training Certificate; to increase and enhance the human resource capacity to deliver quality mathematics, science and technology education.”*(Department of Education, 2001a).

⁵ NQF is the National Qualifications Framework

This having direct relevance to Ridgepark College where in excess of 70% of the learners can be defined as historically disadvantaged by virtue of their race being African and their gender being female. It also shows the emphasis and need for a mathematically, scientifically and technologically literate workforce, affirming the intent of the Mathematics Department Policy of Ridgepark College.

Further, an extract from the **Aims of the National Curriculum Statement** reads as follows: *"To make education for justice and social citizenship a key feature of a curriculum designed for a non-racial, non-sexist, and democratic South Africa"*(Department of Education, 2000c). Among the **Strategic Objectives of Curriculum 2005** it is stipulated that, *'mathematics should be sensitive to gender, racial, cultural, environmental and language issues'* (Department of Education, 2000f). **The Draft Intervention Strategy for Maths, Science and Technology education:** Expresses the concern that, *'as the leading trading nations of the world are moving towards knowledge- based economies, with knowledge workers comprising the bulk of the work force, is our country ready for the 21st century?* (National Department of Education, 2000a).

In addition, if we review the extract below, section 3.2.2, of the **National Strategy For Further Education and Training 1999-2001**, from the Department of Education:

"Preparing for the 20th century for Education, Training and Work

3.2.2 *A strategy will be developed to ensure the achievement of better and equitable participation and achievement in FET. Of great concern has been the low level of participation and achievement in the fields of Mathematics, Science, Technology and Engineering. The strategy will therefore pursue ways to increase learner participation and improve achievement in these fields. Women/Girls will constitute a strategic priority in the elaboration and implementation of such a strategy"*(Department of Education, 2001b).

Mathematics education policy thus, increasingly reflects the need to improve the representation, participation and performance of women. For many women Mathematics is a powerful way of knowing and a system of knowledge working to exclude them. Hartsock (1983) provides a significant catalytic impetus for this study

when she acknowledges that women because of their subjugated position are able to provide more adequate, objective views for transformation because they have less to lose. Myself and my group of girls, the author and co-authors of this study, will try.

I can infer that these are an acknowledgement, of the value that is attached to the participation and achievement in mathematics and that, while females are participating in mathematics, the ideal is, to strengthen and prolong their involvement in mathematics further, in study and career paths. This is seen through the repetition, in policy, of the need to address previous gender and economic, skills and employment imbalances. The exposition of the policy on 'macro' (national policy) and 'micro' (Ridgepark College Mathematics Department policy) levels, alongside each other in this study, serve to show that several of the values are repeated and re-emphasised. They should also inform the lens with which the data is read and interpreted, further on in the study. The brief discussion that follows, on current mathematics practice, will briefly outline current mathematics practice, that is, the context pertaining to my experience, in which these policies are made operational.

1.3.2 Mathematics Education Practice

The senior certificate examination is the first external check on performance in our school system. The number of those achieving matriculation exemptions in the senior certificate is declining (Department of Education, 2000d). By comparison with other middle – income countries our learners seem to perform badly on internationally standardised tests of maths and science such as the Third International Mathematics and Science Study (Howie, 1997). I can map out the following scenario: school leavers become job seekers or enter higher education with consequent gaps in fundamental knowledge, reasoning skills and methods of study. The number of young people in general, and females in particular, that study mathematics with any degree of understanding and proficiency, would by deduction, have declined, when it should be increasing rapidly. This, in my opinion, creates for us a society that is largely, mathematically illiterate, from which, the pool of recruits for further and higher education in science and mathematics based professions would shrink. Yet, alongside this, there is the inescapable and urgent need for us, in South Africa, to engage with the dominant techno- economic paradigm and to enter the global arena.

How realistic have our translations and adaptation of policy been? Have we, as teachers been successful in marrying policy and practice? My estimation is that in the vast majority of classrooms, mathematics is taught the way that I remember it for the last twenty years. Policy has remained largely the ideal and removed from classroom practice. Teachers, handle gender, class and race imbalances as though they don't exist and by doing this, feel safe in the assumption, that we are treating everyone equally. Mathematics is portrayed as an objective truth, and if we have textbooks, then they hold all the answers. The assembly line of mathematics learners ceases at the end of the matriculation examination where these supposed clinical and objective conditions should have us spitting out very objective and predictable outcomes.

I will show that the passes in higher grade Mathematics, occur along disparities of race and gender, using an examination of matriculation results from 1997 to 2000. These disparity trends then, unfortunately compound, into university streams and employment options. It was these repetitive smoke signals, throughout my practice, that propelled me to examine the participation and performance of females in mathematics and the choices that they made post-matriculation. I have chosen to focus on females specifically, as my experience at an all girls school has lead me to believe, that they do learn mathematics differently and that the social context can predict mathematics success or failure. I have further expanded on the participation and performance in mathematics, along race lines, in chapter four to further illuminate this disparity.

Chapter Two - The Literature Review

Those who do research belong to a community of scholars, each of whom has journeyed into the unknown to bring back a fact, a truth, a point of light. What they have recorded of their journey and their findings will make it easier for you to explore the unknown: to help you also to discover a fact, a truth, or bring back a point of light.

LEEDY, 1991

2.1 An Overview

This chapter will elaborate on the feminist perspective from which the data obtained will be analysed, as well as explore literature that has dealt with female participation, performance and choice in mathematics.

2.2 Mathematics - A Feminist Perspective

Kilpatrick (1992) recognises that traditionally, the central concerns for mathematics education have been derived from mathematics and psychology. Questions, pertaining to feminism for example, that are not related to these traditions, he states are regarded as incidental and get transformed or consigned to the periphery. They are regarded as standing outside the formalist, recognised and accepted conventions and struggle for legitimacy. Secada (1995) reminds us that when we forget or ignore the socially constructed nature of any field of enquiry, or, practice and accept that the premises and the historical agreements that created the field as unquestioned givens, then, consensus building becomes silencing, appropriation becomes expropriation, and concern for what is central becomes marginalizing. This study recognises that the voices and contributions of women to mathematics have suffered this silencing and mathematics education research needs to expand to give legitimacy to this feminist view.

Feminists believe that we can better understand the world by studying the relations within it. We are compelled to examine our position in relation to others and that our perspectives are influenced by our own value systems. Not all studies can be subjected to the straight linear progression of the scientific method, when there are subjective variables that resist measurement. Due to the multitude of explanations and interpretations feminism allows a multiplicity of truths, a declaring and an acknowledging of values that are underlying. It acknowledges and critiques what is said as well as what holds silence. Secada (1995) observes that scientific global methods are sound but some practices, procedures, assumptions and findings are biased against women. It is imperative, therefore, that in my limited sphere of a classroom, and as a researcher, that these practices be identified and curtailed. Gender bias can affect the outcome of any study : it can dictate the research direction by influencing the framing of the research problems, it can affect the methodological direction, the sample chosen, the gathering of information, the analysis of the data and the results. Secada (1995) lists a form of bias as the drawing of conclusions about the general population based on the study of males and the interpretation of research findings in relation to male norms. Feminist empiricists frequently argue, that the elimination of these biases allow the emergence of new constructs that can provide alternative descriptions and explanations of the world.

This study assumes a feminist gaze. It is a study especially of females in mathematics, where vast gender disparities in terms of participation, performance and career choice, demand attention (Department of Education, 2000b). It does not look through the conventional male – orientated lens. It contends at the outset, that mathematics has over the years to current practice, been institutionalised as a male domain (Forgasz, 1996). Females may enter the sphere if they are able to adapt and conform to the way that mathematics is learned, taught or developed with its resident 'maleness'. The feminist standpoint introduced by Nancy Hartsock in 1983 (Damarin, 1994)-was conceptualised from Marxist epistemology, particularly from the Marxian notion of the proletarian standpoint. From our subjugated standpoints,' as women, we can deliver more adequate, sustained, objective, transforming accounts of the world. We have less to lose in changing the status quo, we are less bound to it and are better able to examine it (Harding, 1991). Feminist standpoint is an achievement and not a

birthright where people do not automatically come to know the world in a feminist way (Haraway, 1991). A feminist view must be actively pursued and constructed as a way of knowing. Multiplicity is implicit in feminist standpoint theory. There are multiple feminist standpoints (Damarin, 1994). Mathematicians do not stand outside of the mathematical systems that they study. The way that you understand the mathematics is material to the truth constructed (Damarin, 1994). Within the feminist standpoint - it is imperative for women to construct knowledge beginning with knowledge about their own lives and experiences (Damarin, 1994).

Feminism acknowledges that knowledge is always political and never value-free (Damarin, 1994). What this study has acknowledged strongly about this perspective is that, it rejects the idea that our bodies are blank slates on which society writes its messages. Blank slates imply that women are left without agency (Damarin, 1994). Harding (1991) concludes that the feminist standpoint entails a radical objectivity, where knowledge is achieved through the reciprocal relationship between the knower and the object of knowledge. He places the object and the knower to exist in the same critical plane. The objects of knowledge are not seen as static or passive. Knowledge is constructed dialectically through interactions between object and knower (Haraway, 1991). The traditional view of mathematics knowledge as fixed and unchanging is rejected. The world and mathematics are not givens but operate over time and space (Damarin, 1994). Feminism concerns itself with the way that school mathematics has traditionally disadvantaged girls, because of the way that girls tend to think and work and the ways that they come to *know*.

Secada (1995) asserts that people should speak for themselves. To qualify what he is saying he refers to 'voice' as the discourse that is created when people define their own issues in their own ways, from their own perspective using their own terms - i.e. speak for themselves. In this study, we will hear female voices, talking about their experiences in mathematics, speaking for themselves. To understand why female voices are silenced in mathematics, Secada (1995) explains that groups exist because of the boundaries that they establish and maintain, the discourse patterns that they validate, that will affirm their membership. In mathematics, this membership has been predominantly male. This parades a dominance (of males) and a consequent silencing (of females), where it has been impossible to raise issues that oppose the

dominant thought. The white, male, middle class dominance has silenced the female voice. The struggle for voice is that we have to listen to how diverse groups perceive their educational status in general or their mathematics education in particular (Secada, 1995). How do women experience mathematics? They no doubt construct meaning through the receipt of messages about mathematics. Burton (1990) argues they must experience mathematics an area of competing tensions. Patriarchy is pervasive in society in general and in mathematics in particular (Brutsaert and Bracke, 1994). Feminist research must help us better understand the condition of women and to decrease the power of patriarchy over our lives. To continue to do mathematics, a woman has to ignore or redefine the convention that establishes mathematics as a male domain. In this technological age, with information as the new capital, understanding mathematics and the ability to mathematize is an important aspect of social power. Women currently are not considered or seen as equal participants in mathematics. We must claim the right to learn mathematics and have the mathematical knowledge that we have constructed recognised as valuable and acknowledged in the curriculum and instruction.

As women, we come to know and understand the world through the study of the relationships therein. How we regard our place in the world is crucial to the way we react, interact, and the way that we perceive our choices. Any feminist study acknowledges the value-laden aspects of its endeavour and acknowledges that every feminist investigation begins with the lives of women (Damarin, 1994). Female life experiences are critical, so that the female world of mathematics can be rewritten from a female perspective. They are the subject's co-authors (Willis, 1992). Willis (1992) further argues for females to have the opportunity to interrogate their internal perceptions and ways of knowing. In my study, the girls that have participated write their mathematical life stories, in which they give sound to their mathematical voices. They are to be recognised as the study's co-authors.

2.3 Participation in Mathematics

Globalisation and the technological age emphasise intellectual capital—mathematics proficiency is central to these power relations (Department of Education, 2000b).

While women have earned the right to learn mathematics, they are still to be recognised in the creation of new knowledge and the organization of mathematics. Damarin (1994) recognises that women, who choose careers in mathematics and science, are fettered with the gender-structured roles of those careers and the broader social life. Terry (1993) agrees that social processes operate to maintain the status quo. The first woman conferred with a doctorate in mathematics by the University of Durban Westville happened, in 2001 (Post, October, 2001). See article, next page, "The First Doctorate Conferred on a Female...". It is a sad reflection of a society when we have to celebrate women's achievement in mathematics as an exception.

Schools play a critical role in the perpetuation of gender structures (Grossman, 1994). Willis (1992) notes that school mathematics, in particular, can be linked to the maintenance of privilege of some groups over others. She further categorises the successful learner in mathematics as "*middle class, male and belonging to certain racial groups*". Forgasz (1996) concurs that males remain advantaged within the confines of certain mathematics learning environments. How then can we encourage the participation of females in mathematics and assist their performance? Teachers need to be cogniscent of the way that females learn mathematics and the messages that they give out about mathematics. On a very practical level, teaching/instruction methods can be adapted with consideration for the ways that females think and learn. What would we understand female friendly instruction to be? How do they think and learn in the subject?

Damarin (1994) lists the following as the tenets of feminist teaching: the avoidance of sexist behaviours, the proactive linking of mathematics as linked to later opportunity, the use of co-operative groups and the provision of a safe, non-competitive classroom climate. Head (1995) showed also that girls prefer a co-operative learning environment, compared to boys who prefer competition and pressured environment. Becker (1995) and Belencky (1986) take Gilligan's notion of separate and connected to suggest that women and men have different preferences for ways of knowing and subsequent ways of working. Women tend to value 'connected' knowledge that involves intuition, creativity and experience. Men value 'separate' knowledge that is characterised by rigor, logic and abstraction. Becker (1995) claims that girls have been denied mathematics knowledge because they tend to be connected thinkers and

traditional models of mathematics teaching encourage separate ways of working. Thus, to cater for girls we need to offer an open, discursive and experiential form of mathematics that enables separate and connected thinking (Boaler, 1997). Burton (1990) supports the theme that open problem solving environments, produces equity amongst students.

The First Doctorate in Mathematics Conferred on a Female

University of Durban Westville 2001

Dr. Paranjothi Pillay

Hard work all adds up

POST, OCTOBER 2001
NEESHA MAHARAJ

THE challenge of solving mathematical problems spurred University of Durban-Westville mathematics lecturer Ms Paranjothi Pillay to achieve her doctorate in mathematics.

Ms Pillay 38, will be the first woman to be conferred with her doctorate in mathematics by the University of Durban-Westville at a graduation ceremony at the Joosab Hall on Friday.

To obtain this honour she researched the "Iterative Approaches to Convex Feasibility Problem".

Her research provides mathematics enthusiasts with a step-by-step guide to find methods to solving mathematics problems. This was a challenging research that took Ms Pillay four years to complete.

The Scone Road, Westville, lecturer said she was filled with "a sense of relief" on hearing she was successful in obtaining her doctorate.

"It is a nice feeling to have finally obtained this academic qualification after four years of hard work. Being the first woman on the campus to obtain this qualification makes it more special."

A passion for the subject and the challenging subject matter she had to research had inspired her success over the last four years. She said the support of colleagues and family had helped.

Ms Pillay, who has lectured in mathe-



Mathematics lecturer Ms Paranjothi Pillay
Picture: CHIPPY DEVJEE

matics at the university for 16 years, said her interest in the subject developed from her days at school.

"To me mathematics is a beautiful subject. There is always a logical way in finding a solution to a problem. Many people dread it but I love the challenge of solving a mathematical problem."

She urged women who had a keen interest in the subject to pursue it at tertiary level. She said that hard work and dedication were bound to result in success.

There are two different forms of mathematical knowledge: the first is viewed as inert, inflexible, and tied to the situation or context in which it is learned. The second is viewed as adaptable, usable and relational (Lave, 1993). In the first view above, the students develop an inert, procedural knowledge because they learn the teacher's rules and methods without really understanding. In real or applied situations, they are forced to look for cues that may indicate what they have to do. They then rehearse the rules, rather than think mathematically (Boaler, 1997). The way the teacher would view mathematical knowledge, would impact on the teaching approach that is used. Boaler(1997) describes the way that different teaching approaches to learning, help students to view mathematical concepts and procedures. She identified that problem-oriented approaches to learning, as helping students to view mathematical concepts as useful tools that they can use in different situations. More traditional approaches she notes, view concepts as difficult ends to be tolerated rather than as exciting inventions (tools) that allow a variety of problems to be solved (Boaler, 1997).

In the algorithmic approach, the predominant approach in mathematics teaching, students view the procedures as learned entities, useful only for solving school textbook questions. They do not hold the view that the algorithms they were learning are exciting and useful inventions, that would give them the opportunity to solve different mathematical problems. An open approach, therefore, allows mathematics to be active, exploratory and adaptable. It will enable learners to adapt and change methods and to think mathematically. Gibson (1986)- cited in Boaler (1997)- notes that *'When individuals develop meaning out of a situation, they do so through a process of perceiving and acting, and by creating meaning on the spot, rather than using their memory of representations that is stored in their heads'*. In Gibson's theory, the concept of memory becomes non-existent or irrelevant to the explanation of knowing and learning, replaced by the emphasis of tuning of attention and perception. It has been my experience that success in new situations, is due to the ability to perceive and interpret what is needed in situations, combined with, the ability to adapt and make use of procedures that are remembered. Boaler (1997) confirms this in her observation that perception and interpretation of situations is the key to effective learning because the development of meaning helps learners to reflect on prior experience, *"Thought and interpretation must enable the memory of the mathematics that has been used to be enacted"*.

Lave (1993), asserts that students do not use Mathematics learned in one situation in another situation because the two situations represent different 'communities of practice'. The students relate to them differently and form different ideas in relation to the two settings. Bernstein (1996) calls educational knowledge 'uncommon sense knowledge' where students, particularly in our classrooms at present, are socialised early into knowledge frames that discourage connections with every day realities, emphasising the idea of 'separateness'. That knowledge is constructed in different situations separately and in different ways and not transferred from one situation to another is a point of concurrence of the researchers mentioned above.

Traditionally, mathematics is learned in very 'focussed' environments (Boaler, 1997). Questions have one answer; the content is specific and closed and passes through logical steps. Mathematics teachers provide learners with the processes that can be used to solve problems - the algorithms. Questions are usually short and factual requiring little reasoning or interpretation. The problem is stripped into smaller parts that can be handled algorithmically. By doing this, they believe that they are helping learners. Students then learn a sense of 'helplessness' (Boaler, 1997) around problems when this is not done. Spencer and Steele (1994) suggest that when females are frustrated with the level of difficulty of mathematics problems, they associate this with the belief that women are not supposed to be good in mathematics. They found that when males and females that are successful in mathematics were tested, on fairly moderate type problems, there was little discrepancy in the way that they performed. However, on more difficult type examples, males would out-perform females. This seemed to confirm the predominant literature.

It has been my experience that teachers actively discourage students from thinking about mathematical relationships by telling them rules that they should remember. Bernstein's collection code (Bernstein1997) states that there is a tendency ... "*for the young to be socialised into principles and routine operations and derivations*". The evaluative system in addition, places an emphasis upon attaining states of knowing rather than ways of knowing. We as teachers expect that learners could not and would not know how to learn mathematics, learners do not learn how to learn and this perpetuates the problem.

Boaler (1997) found that girls are interested in meaning and understanding. Boys relate to speed and attainment of correct answers, rather than understanding. They regard mathematics as a system of rule following and rote – learning. Thus they are more easily accommodated in the school system. Dweck (1986) found low expectations, challenge avoidance, ability as reason for failure and debilitation under failure amongst high achieving girls.

Further findings, were that girls seek situations that will lead to good performance rather than situations that would involve challenge and in which they may learn. Boaler (1997) found that the high pressure of the mathematics classroom does not foster learners seeking the challenging situation. Girls, in particular, become anxious in such situations, rather than repositioning their goals and replacing their desire for understanding with the desire for speed as boys do. The negative attitude amongst bright girls and the inequities when compared to boys derives from the intrinsic features of the mathematics classroom rather than the personal inadequacies of the girls themselves (Leder, 1996). Girl's disaffection and underachievement can be related, not to their own shortcomings, but to the way that the mathematics was presented, in fast and pressured environments.

Females learn mathematics differently to males; teaching has neglected to be cognisant of this. Teaching continues in patterns that disadvantage females and ignores their learning preference. The resultant perceptions about mathematics that females get and keep, unfortunately, follows them even when they complete school and determines whether they opt to continue with mathematics or not.

2.4 Choice in Mathematics

Many learners criticise mathematics for its lack of utilitarian value out of school. They maintain they will never use what they have learned. Lave (1993) and Lave and Wegner (1991)-cited in Boaler (1997)- proposed that notions of transfer cannot explain the way that individuals use knowledge in different situations because transfer

theories do not take into consideration 'communities of practise' in which people operate. Schools they categorise as specialised communities of practise unrelated to any other, when considering, the formalised nature of the mathematical knowledge, the lack of social interaction and the imposition of school rules. This encourages learners to locate all mathematical knowledge within the four walls of the classroom. It has implications for the options, in study and career path, that girls perceive as available to them (Bishop, 1994). The boundaries therefore between school and the real world need to be less rigid, where schools encourage learners to use mathematics to solve problems that they themselves have posed (Boaler, 1997). This study is unable to discount, the dominant part that schooling plays in reproducing the status quo with regards to gender structures.

Mathematics has been identified as a stereotypically masculine domain and is antithetical to cultural stereotypes of femininity (Ernest, 1991). A number of researchers, including Burton (1990), Fennema (1993), have shown how these types of beliefs impact on women. They in essence feel that women have to choose to be feminine or to be successful in mathematics. Being both, presents women with the obvious and socially uncomfortable contradiction, Mathematics \neq Feminine. Women win social approval and reward, from all sides (parents, peers, friends and society) for following the conventional path of femininity. It is a natural tendency for people to crave and work for approval. Ernest (1996) says that women are thus coerced away from mathematics and that it impacts on the way that women view themselves in mathematics and the way that they perform. Females in mathematics are consequently, regarded as inferior and the efforts of those that participate have their successes discounted (Walkerdine, 1989). This tendency towards lower participation, manifests in unequal opportunities in study and work, with women falling into lower paid jobs (Ernest, 1991). This tendency marking trends in female career choices had its origins with Lucy Sells' 'critical filter', to be discussed later.

Once we have succeeded and created the environment for females to perform well in mathematics, we have to examine if a career in mathematics offers women the kind of life that they want to lead (Baxter, 2001). Women generally have to conform to the gender structures of those roles, particularly in careers in mathematics and science,

which mirror broader social life (Spencer, 1994). Those that succeed often do so at large personal cost (Forgasz, 1996). Willis (1992) notes that women often make decisions without conscious awareness of social forces. With a university that can boast it's first woman doctorate in 2001, it is easy to conclude, that contemporary mathematics reveals an overwhelmingly male picture. Seliktar (1998) found that in the early 1990's, one fifth of all mathematicians and scientists in the United States, were women. Yet, at the time, half of the people entering the workforce are women and this is First World! A calculated assumption on Africa would be bleaker. The overwhelming view of prevailing literature on equity in mathematics and mathematics education emphasises that both males and females must develop a gender critical understanding. Forgasz (1996) concurs that without men, a gender study would be only a partial and distorted discourse.

2.5 Factors Relating to Performance among Females

The department of education is clear, that we need to adopt a gender equity perspective (Department of Education, 2000b). Parker (1996) calls for teachers to provide mathematical learning experiences that incorporate girl's experiences and interests into class discussions. Boaler (1997) and Parker (1996) concur that girls should be presented with problems that are realistic and that require them to learn new concepts and ideas in order to solve problems. Females should be given the opportunity to explore different ways of solving problems outside of the specified format of the mathematics textbook and the classroom (Boaler, 1997). This should encourage and challenge them to explore beyond their standard, conventional algorithmic borders. The way that these borders are created, and their inherent control is then exposed. Girls will then be allowed choices about the organisation of their work and whether they wish to participate at all. This breaking the routines that creates Lave's (1996) 'separate communities of practice'. Boaler (1997) observes that these practices translate easily to the real world. That procedural knowledge is then inextricably linked to the situation and is in itself not an end. This she stresses encourages the delimiting of procedural knowledge so that it can be located in the wider mathematical perspective. She also found, that remembering methods relies on

memory and cues and is often forgotten after the exercise and that these cues are not present in authentic tasks or non-school mathematics. Females need to form a belief in the utility of the mathematics and they must learn and regard mathematics as usable and adaptable (Boaler, 1997).

The mathematics that we come to know is often parcelled and taught in arbitrary bits, the process largely controlled by the teacher. The abstraction that we encounter in mathematics is frequently dealt with by the teacher on behalf of the student (Belenky, 1986). We compel them to learn what we teach but hardly enable them (Johnston, 1996). We need to encourage willingness and ability, among our female learners to perceive and interpret different situations and develop meaning from them. We still need to provide sufficient understanding of procedures, for procedures to be drawn on. A mathematical confidence that allows particularly females to adapt and change procedures to fit the demands of a new situation has to be prioritised and developed.

On the framework of this study: Burton (1990) categorises the gender in education debate into 5 parts. First, the numerical presence of males and females. Second, the subject distribution of males and females. Third, the success rate of women in comparison to men. Fourth, the climate in which learning occurs, in particular, the impact of single compared to mixed sex schools. Fifth, the assumption that learners can be offered the same educational experience, despite a growing literature that challenges this.

This study examines these categories. While the levels of women gaining qualifications are increasing, we have to question, why certain qualifications and career paths continue to remain biased. There is a shortage of literature that could assist this study in comparing ourselves with global trends.

2.6 Women's Participation and Performance in Mathematics- Historic Identities and Roles 1970's – 2000's

In order to understand the contexts in which women currently operate in Mathematics it is necessary to understand and illuminate the historical paths, as explored in literature that their involvement in mathematics has traversed.

Literature reveals that women work under the constraint that their ability in mathematics will constantly be undermined, their potential will lay largely untapped and they will be directed into the roles that require little or no creative ability, decision making, or complex application. Hanna (1998) observed that, in the 19th century, calculation and computation were thought to be mathematics outside the domain of acceptable female behaviour. With the industrial revolution there arose the need for cheap labour and performing routine calculations. arithmetical competence no longer was beyond the abilities of women. Today, this competence is a lower –level skill and is associated with women. The recognition of women's spatial abilities has also shifted this competence in a negative direction. Women appear to lack confidence in their mathematics ability as a consequence, the value of their mathematics knowledge is continually undermined and they are trusted with the mundane /routine processes in mathematics. Hanna (1998) calls this the 'othering' of women in mathematics, where society sees the mathematician as white, male and remote from the realities of every day life. Women are always credited with the struggle to balance the demands of career, family, wife and mother.

Lucy Sells in 1975, at the university of California, originated the idea of the 'critical filter'. She investigated the relationship between secondary school mathematics preparation and female's subsequent choice of a major. She found that females on campus had received far less preparation in Mathematics at high school, than males. That females were under-represented in advanced courses. Women were unable therefore to choose from as wide a range of majors that required calculus or statistics. She concluded that this steered the majority of women to lower paying jobs after graduation and further, that the stereotype of women not being able in mathematics,

was so pervasive in the culture that few questioned it. Sells then tried to convince, that the attrition of females began much earlier in girl's lives (Damarin, 1994).

Attempting to find answers to the gender disparity in mathematics achievement, in the 1980's, some researchers argued a biological explanation (Benbow, 1988). Others focus on environmental factors: differential course work, home support, the sense of mathematics as useful, the sense of mathematics as a male domain or the teacher – learner interaction (Fennema and Peterson, 1990). Stanic (1995) concluded that socio – economic status interacts with gender to influence mathematics learning. Friedman's Meta -Analysis of Mathematics Achievement (Fennema, 1992) points to an emerging trend that gender differences in terms of males is decreasing, after exploring environmental and social changes. Confirming Stanic (1995), these studies gave weight to the mathematics environment and not biological characteristics as being responsible for mathematics learning.

Consistent findings from research on gender and mathematics in the 1980's found also that when mathematics became an option in secondary schools, fewer females than males elected to study it (Taylor, 1986). That, women did not believe that mathematics was particularly useful and tended to have less confidence in themselves as learners (Casserly, 1985). Boys, especially, stereotyped mathematics as a male domain and that this sexist environment in a classroom increased girl's anxiety about mathematics. Fennema (1995) notes that many studies also concluded that there are many societal influences to suggest that mathematics learning is not appropriate for girls. For the sake of balance it must be noted that many of these earlier studies, were American, yet the pervasive sexism is easy for myself to relate to as a female in mathematics. In addition, the USA is a heterogeneous society, very much like ours with multiple cultures, layers and classes and the findings are, only with prudence, thus relatable.

The literature of the 1990's showed the following trends: that gender difference in mathematics was decreasing however, gender differences in mathematics still existed in the areas of learning of complex mathematics (Hanna, 1990). There was investigation into personal beliefs about mathematics and about career choice that involves mathematics (Jurdak, 1994). Into how classrooms were structured to favour

male learning, and, interventions that could be introduced to achieve equity in mathematics (Bell, 1993). Other basic trends of education research in the 1900's dealt with the transmission of knowledge, setting, control and order. The emphasis on control and order, pointed to encouraging students to follow specified methods and rules (Sigurdson and Olsen, 1992). Boaler (1997) explains that such learners were found to be inflexible or unable to adapt, did not think critically in mathematical situations, demonstrated passive, unchallenging acquiescence in lessons. This she attributed as a direct result of the school's conditioning towards conformity, order and obedience, an acceptance of school and mathematical rules and a dependence on the structures that provide these rules. Dependency, it was found, resulted in learners being extremely well behaved in lessons and lacking critical and independent thought.

This study will show that gender differences may be decreasing in terms of participation of females compared to males, but performance differences remain wide. The basic premise of the International Commission for Mathematics Instruction Study Conference on Gender and Mathematics in 1992, emphasised this further, that there is no physical or intellectual barrier, to the participation of women in mathematics (ICME, 1992). Consequently one has to examine why there are still vast differences in performance and in female involvement in mathematics related careers. This shows that while females are able to learn mathematics many opt out of studying mathematics further. We need further research, to facilitate and encourage the learning of mathematics by females so that they succeed. Much research about females in mathematics, particularly of the 1990's, points to independence in mathematical thinking and learning through working in co-operation to solve mathematical problems. Competitive learning environments have been shown to inhibit girls in mathematics (Kahle, 1990). The Autonomous Learning Behaviours Model acknowledges that, because of societal influences (of which teachers and students were main components) and personal belief systems (lowered confidence, attributional style, belief in usefulness), female students do not participate in learning activities that enable them to become independent learners of mathematics (Fennema & Peterson, 1986). So females are participating, but in ways and an atmosphere that hinders their success and fulfils the notion, that mathematics is not a female domain.

Walkerdine (1989) and Willis (1992) showed that teachers attribute female success in mathematics to hard work and male success to ability. Hanna (1992) develops on the arbitrariness of the sequencing of mathematics instruction, that the prerequisite knowledge is often not applicable in subsequent contexts, which leaves students confused about their mathematical ability. In my experience, the matriculation syllabus reflects this arbitrariness; with students learning sections separately and that show little connection. Further, for females, the absence of societal messages, affirming mathematics as a female domain, of personal intuition and the opportunity to build thereon, the teacher's recognition of the ability and the opportunity to apply knowledge to subsequent courses, leaves women with little confidence in themselves as mathematicians. The classroom and social structure appears to limit girl's involvement in mathematics and not the girls themselves. Most research has been unable to show a single answer to the questions that they pose, but show a strong interconnection between mathematics achievement, socialization and the individual.

21st Century thought regards, the encouragement of flexibility and adaptability, as an important role for mathematics education in the future, as a necessary response to the development of technology and the changing nature of the job market (Boaler, 1997). Current thought is critical of prior research where the under-representation of girls in mathematics related careers was often analysed on the basis that the problem was between girls and mathematics (Willis, 1992). That *there* learning styles may be deficient, that *they*, are not able. The assumption is, that female's lack. We then try to change the girls and not the mathematics, to make the two more compatible. This ignores the role that society, teachers and schools play in what we learn and how we learn. If you can change a girl, to love mathematics and then put her back in the environment that caused her to hate it in the first place, she will revert to hating mathematics again (Campbell, 1989). Girls tend to doubt their competence in mathematics and seem to be less confident in their ability (Leder, 1980).

Much recent research, that of the 1990's – 2000's, has as emphasis, the absence of women in the employment spectrum. It also overwhelmingly shows that the reasons for girl's absence in mathematics is not solely located in the girls themselves as much of the earlier research showed. The economy and pressure to join with global players has seen many women return to the workforce and industry opening up opportunity

for employment. It is here that we notice the absence of women in careers that pertain to mathematics. In summary, the 1970's and 1980's saw an increase in the participation of women in mathematics. Literature of the late 1990's to date examines the way that females are performing and what careers they are choosing (termed 'choice' in the rest of this study).

2.7 The Nature of Mathematical Knowledge and Society

2.7.1 Learning Mathematics in a Changing Social Context

Every child can learn mathematics. We have thus to structure the mathematics environment so that every learner irrespective of gender, race or language can learn mathematics. The current sanitised, widely suspected value-free organization and structure, of the mathematics classroom (Willis, 1992), has to evolve to embrace the multi-cultural, multi-lingual, and dynamic of the classroom and society as a whole. Instructional activities must be organised and embedded in multi-cultural contexts to help learners develop a strong sense of identity with the roots of their own culture as well as the knowledge and belief in the importance of multi-cultural society (Secada, 1995). In the South African context that would mean, addressing those who the previous apartheid education most disadvantaged, our African learners, and then those, that have been disadvantaged by sexist practices, women.

Currently, all learners in South African mathematics education are disadvantaged in that they have no participation in the content except for learning it as an external measure. Fenema (1993) observed that when the mathematics taught has been too narrowly defined, it limits the mathematics-learning trajectory of the disadvantaged student populations. Adding content on ethnic groups and women compromises and does not address the academic performance (Ogbu, 1992). Such approaches ensure that the perspectives of the dominant culture persist and remain unchallenged (Willis, 1992). Ernest (1996) notes that alternative systems in mathematics have to gain legitimacy by recognition in the curriculum and practice in the classroom. This introduction of alternative forms he maintains, must also ensure, that it is not token but that it actually facilitates the development of mathematics content.

Academic achievements of an individual have been recognised when they conform to traditionally held beliefs about what constitutes success in school. Success has been traditionally defined from a white – male oriented perspective (Willis, 1992). She observes further that what is to be learned and, an individual's way of knowing and behaviour in the school environment are also dictated by these established norms. It is my feeling, that we cannot interrogate the reasons for many learners failing mathematics, without also examining their social contexts. Those that have difficulty in being assimilated into the learning environment will obviously disengage, opt out. If we examine the performance of African Females in particular, in the mathematics matriculation examination: their inability to succeed is most frequently, linked to their inability to learn and not to the content or the learning environment. Learners that are not part of the dominant culture, struggle to make sense of the learning environment, its rules and regulations and to adapt to the situation. They're at the same time trying to maintain their identity. Mellin-Olsen (1987) among many other researchers suggests that we engage learners in mathematical activity that is embedded in the learner's social and political context.

In a changing social context, practice in the classroom has to change alongside curriculum change. Damarin (1991) lists one of the widely held tenets of learning mathematics is that it should be learned with understanding. Billings (1991) notes that students that are treated as competent are likely to demonstrate competence. Teacher's expectations impact on student performance. What messages are the African Female learners receiving about mathematics if year after year their results are scandalously poor? To what extent are teachers, particularly those at newly integrated schools, enabling or limiting their performance? Johnston (1996) observes that our prejudices also enable our perceptions. Gee (1987) suggests an explanation for the wide difference in literacy achievement between African –American, lower and middle-class students and White middle –class students. He contends that white students are often treated as they already have knowledge and experience instruction as an apprenticeship. African - American students are treated as they have no knowledge and experience instruction as teaching. By definition, as an apprentice, you can perform tasks that you have not fully learned. From experience, I have seen that learners that are Black have English as a second language or are from poor socio

economic conditions are taught neglecting their prior knowledge and are expected to conform to entirely new ways of knowing mathematics and thinking.

2.7.2 Mathematics For Equity

A gender critical understanding on the part of both men and women is necessary to bring about equity in mathematics. An increasingly large proportion of our society is composed of people who are the least well served by our current educational system (Silver, Smith, Nelson, 1995). Notions of equity have to be linked to policy and practice and seen in pragmatic efforts of redress. Classical notions of equity in the literature, centre around: the equality of educational opportunity, equity as a quantitative construct, or equity as focussed on inputs, processes and outcomes of education. There is a very substantial part of equity that is value laden and qualitative, and neglected, in our attempts for redress. However, relevant to our practice, Billings (1991) describes the characteristics of teachers that are successful in teaching African American students. She found them able to show a personal interest in their students beyond the classroom. They maintain high standards and commitment to their students concurring with the apprentice theory of Gee (1987) above and they celebrate success not just in mathematics, but also in life. They display an excitement to their subject that helps breathe life into a subject that can so easily prove dull and uninteresting. Numerous studies (Sadker&Sadker, 1994) have identified the attitude and views of the teacher as amongst the main determinants when students exercise choice in their subjects.

In South Africa, a focus on mathematics is justified because of the unacceptably low achievement in mathematics amongst African learners (see statistical tables in Chapter 4). Demographic trends predict the socio-economic landscape of future decades. As it stands, an increasingly large portion of our society, who happen to be of a specific race group, Black African and who are also the most economically disadvantaged are least well served by the education system. Knowledge of mathematics (Secada, 1995) supports a productive, technological, powerful elite, while a dependant, semiliterate majority, disproportionately Black, find economic and

political power, beyond reach. The National Research Council, in its report *Everybody Counts* (1989) states: *“Demographic trends indicate, that continued under-investment in the education of the poor, will exacerbate the current achievement gaps between groups in society, hindering progress globally”*. We need efforts to create a society that offers opportunity to all its members to be successful and to contribute to social and economic good. This compels equity to be addressed in mathematics so that all children have equal, improved access and opportunity in mathematics to allow access into employment and further education opportunities.

By influencing maths achievement and attitudes at junior secondary level, greater numbers of historically disadvantaged can be better prepared for more challenging mathematics beyond school (Secada, 1995). Ernest (1996) concluded that to develop higher order cognitive abilities requires shaping the disposition to thought through participation in social communities, that value thinking and independent judgement. Mathematics classes then become communities of collaborative, reflective practice, where students are challenged to think deeply about, and to participate actively in, engaging the mathematics as they learn (Fenemba, 1993). Silver (1995) spoke for the need of communication in the form of discussion, argument, proof and justification in these communities. Where students are encouraged not only to listen but also to speak mathematics themselves. The emphasis is less on memorising procedure and producing answers and more on analysing, reasoning and becoming convinced.

Many believe that equity could only be measured in quantifiable ways; for example, we have to make sure that a representative number of African learners are to pass higher-grade mathematics. It is my opinion, that this is a half – truth. Teachers and learners have to change mindsets and limitations that they have assigned to mathematics. Careless assumptions that are based on race, language and socio – economic standards and transposed on mathematics ability have to be expunged from mathematics classrooms. Our classrooms need to be structured so that all learners regardless of race, gender or language can learn mathematics. Female learners, especially, need to feel empowered to make decisions about what is appropriate for them in terms of content and context. All learners can learn mathematics, is a good starting point to drive equity. Our classrooms, our interactions

have to take into account how females, learn mathematics. In my opinion, females defer their responsibility for their non-success in mathematics, to the level of difficulty of the subject. They need to take control and responsibility for their learning. And we, as teachers, must make way for mathematics to be more accessible and meaningful for our learners. Fennema and Carpenter (1981) noted that when this is done, learning improves.

Chapter Three - Methodology

Architects, before the construction of a building, work out a meticulous and accurate set of plans. This ensures success in the construction of that building. Researchers should be no less precise, detailed, and accurate in the planning of a research project. Plans, specifications, criteria, and design: All of these serve well the architect, the builder, and the researcher alike.

LEEDY, 1991

3.1 Overview

Research is defined as a studious enquiry or examination, an especially critical and exhaustive investigation or experimentation having for its aim the discovery of new facts and their correct interpretation, the revision of accepted conclusions, theories or laws in the light of newly discovered facts or the practical application of such conclusions, theories or laws (*Webster's Dictionary of the English Language*).

In this study, both quantitative and qualitative data have been used. The qualitative research component of this study incorporates a variety of methods. This study used specifically autobiographies/ narratives, questionnaires and interviews. The purpose of research is to gain understanding of the meanings constructed and the intent of their aims. I wanted to know what the broader South African picture of female participation and performance in mathematics was and then to place the females that I teach into this wider context and to further examine the mathematics choices that they made on completing school. The researcher observes the actors in the arena, taking into account social interactions and collecting data on which to base judgements and recommendations (Leedy, 1991). As a result of this judgemental component the influence of the researcher is important and contentious. Researchers therefore try to neutralise their influence on observations by using methodological techniques of triangulation (Secada, 1995).

The quantitative data involved the exposition of statistics on mathematics from the national education department on female participation and performance in the matriculation examination and statistics of, participation and performance, at three

urban universities that serve the majority of learners at Ridgepark College. The autobiographies/narratives, questionnaires and interviews were triangulated against the statistical landscape obtained from education institutions. The use of multiple methods to answer the same research questions is a reasonable way to reduce bias (Campbell, 1989). Everywhere our knowledge is incomplete and problems are waiting to be solved- Research Methodology to me means, the way in which we proceed to solve problems. It is an operational framework within which the data are placed so that their meaning can be seen more clearly (Leedy, 1991).

Leedy (1991) reminds us that research is not haphazard. It follows standard procedure in a logical sequence of steps that forms its methodology. To provide an overview of the methodology employed in this study, I will elaborate on some of the characteristics of research, that Leedy (1991) has identified, as pertaining to this study specifically. What follows is an interplay between Leedy (1991), in italics, and myself the researcher and an author of this study. The intention is to give the reader an idea of the way that this research project unfolded, how my thinking evolved. Leedy (1991) provided a 'prototype' about which the various stages of this study's evolution could be displayed and it reads as a dramatic script. Such was the context of it's unfolding!

Leedy (1991): 1. *'It begins in the mind of the researcher'.*

Research originates from a curiosity, an observation of a problem that needs investigation or fixing ...

Me: Mathematics related professions appear the domain of males. Females that I have taught and who were very successful at mathematics appeared not to choose these professions. Was this because too few females studied mathematics at school, compared to males? Did this relate to their performance in mathematics when compared to males at school or university?

Leedy (1991): 2. *'It demands the researcher articulate a specific goal for the investigative process'.*

Here the researcher states her problem as simply as possible...

Me: How were females participating and performing compared to males in mathematics at matriculation and university levels?

What informed female thinking about career choice in mathematics?

Leedy (1991): 3. 'It demands a specific plan or procedure'.

This is an articulation of the research method...

Me: This articulation unfolds in this chapter.

Leedy (1991): 4. 'It recognises that a frontal attack on the entire problem is too much to attempt at one time'.

Every problem can be divided into sub-problems. By sub-dividing, it becomes more manageable. It is more expedient to solve smaller problems...

Me: Each chapter in this study evolved from having its goals and intentions listed. From this sprung, the sub-problems. The contents pages reveal this exercise as they list the aspects as they were broken down.

Leedy (1991): 5. 'It accepts certain critical assumptions'.

These are axiomatic and are essential for the research process to continue...

Me: All students can learn mathematics.

Leedy (1991): 6. 'It is by nature a helical process'.

Me: In this study I give a view of the quantitative data, statistics on participation, performance and choices that females make to prepare the broader canvas. I further examine, in-depth, the qualitative data that looks at female's lives and the factors that influence their participation, performance and choice. These provide the finer, more detailed strokes. Once I had established the point of departure, I found that the answers did not evolve in a straight linear fashion, as I had expected. What this study showed strongly was an interconnection and interdependency that saw all its sub-parts relating to and impacting on one another. Much like the twists and connections of the complex DNA molecule, the study wound helically through parts that were connected and affected one another. To illustrate: females participation in mathematics is related to not only what the school curriculum offers but to various social tensions as elaborated in Chapter 5.

3.2 Choosing the Perspective

The positivist perspective has provided powerful and rich information about gender and mathematics, at a macro level. It documents very well, the gender differences in participation and achievement. However, a study using solely this perspective would be limiting. We need to complement or contrast this perspective with other perspectives. Two immediately evoked my curiosity and provided contrast that was worthy of discussion and elaboration: the first, the cognitive science perspective, which emphasises the irrelevance of male/ female differences in the learning of mathematics, provided good contrast and the impetus for explanation to be sought on areas that I perceived it overlooked or generalised. It was consequently, a perspective that this study vigorously attempted to challenge and 'complete'. The second, the feminist perspective which emphasises that male /female differences are critical to the learning of mathematics. There are aspects of both that I have interrogated, opposed, borrowed and challenged.

In the Cognitive Science Perspective, Brown and Borko (1992) define cognitive psychology as the scientific study of mental events, primarily concerned with the contents of the human mind (knowledge and beliefs) and the mental processes in which people engage. Much of behaviour, it suggests, is guided by mental activity or cognitions. It is difficult to get at mental processes, also the data collection and interpretation are different to those used in positivist research. The sample is small and the data provided by interviews (e.g. subjects may think aloud during problem solving). Researchers look for universals that apply to all people. Studies of teacher's beliefs, knowledge and work on learner thinking, use this approach. This perspective was rejected by this study in that it assumed that all students, male or female, learn mathematics in the same way. While I do attempt to examine the cognition (thinking) of females especially around the way they exercise mathematical choice, I acknowledge that their cognition is a product of their socialisation and, that females are treated differently, in mathematics, when compared to males. The cognitive science perspective provides a limited explanation for why learning happens or not. The focus on the learner and mathematics does not take adequate account of the broader contextual factors.

The feminist perspective focussed on interpreting the world and its components from a feminine point of view (Fennema, 1993). Feminists argue that most of our beliefs, perceptions and scholarship, most scientific methodology and findings are dominated by male perspectives or interpreted through male eyes (Damarin, 1994). I agree. Females inherit this subjugation. The major bodies of knowledge that appear to be value free and to report universal truth are in reality based on masculine values and perceptions (Hanna, 1998). We need to gender mathematics to look at the way that people think and learn in the subject (Tobias, 1990). I sought to understand what female friendly instruction is. Another need that informed my feminist perspective is the necessity for female voices to be heard. Their life experiences became critical, so that I could interpret the world from their perspective. We became co-investigators, co-authors, and women reporting our own experiences and helping to interpret the results. Researchers need to examine how a male view of maths has been destructive to both males and females (Fennema, 1993). Mathematics, as it is currently taught and learned, restricts lives rather than enriches them. We need to examine how feminist perspectives can add enriched understanding to knowledge of mathematics education. Male and female differences permeate the entirety of life and must be considered where scholarship is planned (Fennema, 1993). One basic assumption then, underlying this feminist work, is that there are basic differences between females and males that result in them interpreting the world differently.

3.3 Research Design

The critical questions that this study attempted to answer prompted an examination of the following:

In the period, 1997-2000, how were females (in terms of their numbers), compared to males, participating in school mathematics, nationally, provincially and at Ridgemark College? Those females that were involved in mathematics at school or universities, how were they performing relative to males and prevailing performance standards? And finally, if females who were successful at mathematics at school, chose mathematics related career paths?

In summary, it is a three-tiered study that examines the **participation** and **performance** of females in mathematics at school and university, and the **choices** that especially those who are successful at school mathematics, make for careers.

3.3.1 Description of the Sample

There was a deliberate decision to allow the process of the research methodology to unfold in the course of doing the research (Vithal, 1998). To qualify, I had initially expected my 5 participants to write their autobiographies, and from this, to gauge sufficient information to understand the choices they made out of the contexts from which they had come. I anticipated handing journals to 10 learners that I had chosen (largely, on the basis of their performance in grade 11- they would have finished in the top 70% of the class). However, the entire class of 29 learners volunteered. The instruction they received was that they were to recall, with as much detail as was possible, their mathematical lives that had led them to being in the class grouping that had produced the highest average on the grade 11, higher grade, mathematics final examination at the end of grade 11. The classes, at Ridgepark College, are graded and at the end of 2000, these girls would have finished their grade 11 year with mathematics scores above 55%. Of the 29 journals handed out, 20 girls followed through and handed in comprehensive autobiographies of their lives and mathematical lives. The 9 outstanding, volunteered excuses of not having sufficient time and matric related stress, to, having difficulty, disclosing information about themselves (thinking and writing about their past and lives made them strangely fearful). I gratefully, received all journals. Most were comprehensive and beyond my expectations: girls submitted detailed narratives of their lives, they used prized family photographs, drew pictures and told of some of their most personal experiences, fears, hopes and dreams. I reasoned to accept and analyse all 20 autobiographies as data, as these were all 'successful' girls in mathematics. 'Success' being defined in this study as having remained and passing in the main, with assessments above 55% in mathematics, on the higher grade, throughout their mathematical lives. Their initial autobiographies added colour to the landscape that was my classroom gave me an in-depth and personal picture of their lives and prompted an understanding of them, as individuals rather than as a classroom of mathematics students.

A few girls, as already mentioned, found that writing was not at all easy. Nevertheless, they tried and provided detailed and insightful backgrounds of their experiences, lives and their learning in mathematics. I found it surprising also, that many learners were able to open up and disclose aspects of them that were intensely personal, to me, as a researcher that they did not perceive that they could do, to me as an educator. They discussed family difficulties such as the impact of their parents divorce on their schooling or problems that they encountered as adolescents. The mathematics classroom thus far, having provided little opportunity for these discussions. This opportunity, to see a more holistic picture of my girls, convinced me, that questionnaires and interviews were now mandatory. Emphasising Vithal (1998) above, where the methodology unfolded as the research progressed. With the questionnaires I hoped to streamline their autobiographical writing giving emphasis to their mathematical lives. The interviews afforded me an even more comprehensive picture. I saw five girls in their homes, experiencing intimately the context that is perhaps the most influential and defining in the way that they come to 'be' in our mathematics classroom.

3.3.2 The Use of Narratives

A narrative as a research tool is taken from a variety of disciplines (sociology, psychology, anthropology) (Walsh, 1994). In this study, it showed huge potential to illuminate the learners experience and choices. The autobiographical narrative technique employed in this study could be seen to have numerous characteristics. It started with as far back as the girls could remember of their lives, or as far back as they chose to write about. They allowed their experiences to unfold as they told these and they terminated at a point where they deemed was sufficient for my study. They all generally took their experiences up to the week when their autobiographies were due. In presenting their stories to you, the reader, in Chapter 6, be aware that I have selected the details that I report and these are the ones that are important to this version of telling. I have focussed on their experiences, on what they do and on what has happened to them. Their writing included a substantial emotional dimension, by not only including their experiences, but also, how they felt about these experiences. Their stories come across therefore as a plot –which gives meaning to the unfolding events and provides continuity, emergence, unforeseen twists and denouements.

Lyders (1994) admits that this invites interpretation – and if told in groups, it promotes the dialogue of competing interpretations.

After reading the importance apportioned to the scientific approach to research (in Leedy (1991) for example) I had to place the narratives, that provided such revealing and rich data, in this context, and question whether the narrative-autobiographical approach can replace conventional quantitative research. The narratives, in this study, gave a rich picture of the nature and course of each individual's life choices. A story is the means of ordering and storing the human experience and complexity. In their stories it was possible to identify these learners priorities and the barriers they perceived to their behaviour changing. As a researcher I was able to explore the end of the story by suggesting other approaches that may be used or how things could be improved or changed. Narrative research recognises that everyone has different priorities and perspectives, and that all of these are legitimate (Lyders, 1994). Story - telling, the relating of events has a fundamental human quality. It is imperative that research legitimises and acknowledges it as a significant contribution. This is to say, necessarily, that the story itself need not be scientific, plausible or even entirely true but that the analysis to which it is subject be based on sound academic congruencies.

3.3.3 Data Collection Plan

The data collection plan examines the research choices that were made. It describes what was considered appropriate data, the sources of the data and the instruments that were used. Here I attempt to demonstrate who the participants in this study really are and the roles that they play in this study are examined. The merits of the different research instruments that were used are examined and their limitations discussed.

Leedy (1991) calls data, the communicating linkage between the 'ultimate truth and the enquiring mind of the researcher'. Further, he uses an excellent metaphor when he says that the data are like 'ore'. They contain desirable aspects of the truth, but to extract from the facts their meaning, we employ the research methodology. The methodology and the data are interdependent creating in themselves a 'helix', that was mentioned earlier. The data in this study dictated the methodology and vice versa. The methodology being the operational framework within which the facts are placed, so that their meaning could be extracted.

Summary of Data used in the Study

<u>Qualitative Data Source</u>	<u>Units Used</u>
1. Written Autobiography	20
2. Questionnaires	20
3. Interviews	5
<u>Quantitative Data Sources</u>	<u>Sources</u>
1. Performance and Participation Senior Certificate Mathematics 1997- 2000 <ul style="list-style-type: none"> ▪ Nationally ▪ Provincially 	National Department of Education
2. Performance and Participation Senior Certificate Mathematics 2000 – Gender Segregated	National Department of Education
3. Performance and Participation Senior Certificate Mathematics Ridgepark College, where study is based. 1998-2000	Administration Department of Ridgepark College
4. Participation and Graduate Statistics in Mathematics : <ul style="list-style-type: none"> ▪ UNISA-Participation only. 1997-2001. Gender Segregated. All provinces. ▪ UDW 1996-2000. Gender / Race Segregated ▪ UND 1997-2000. Gender/Race Segregated 	The respective Administration Departments

In the section of my study, that involved the narrative autobiographies, which I term the core, I wanted to discover/uncover how female learners experienced mathematics over the different parts of their mathematical lives and how they came to exercise the choices that they did. The statistical data, enveloping the core, and elaborated in chapter four, helped to expose how the female mathematics learners directly involved in the study, fitted in with female learners in the national mathematics spectrum of female participation, performance and choice.

3.3.3.1 The Collection of the Qualitative Data

The primary data was collected over a 10-month period of 2001, in my grade 12, higher grade, and mathematics class. I anticipated handing out journals to my highest achievers, that would be my top ten girls, selected on school/ classroom based assessments. I was pleasantly surprised when the entire group, 29 learners in all, volunteered to be involved in the writing up of an autobiography. This entire group ranked in the top 50% of the total complement of matriculation, mathematics, higher grade learners at Ridgepark College in 2001. These girls appeared to enjoy mathematics, were motivated to understand what they were learning and usually performed well. I reasoned they would be the most likely to select further study in mathematics or to choose a mathematics related career. They were a diverse group of learners along race and cultural lines, but I would estimate similar economic backgrounds, middle class, each having access to tertiary study with parents financial support. I knew of no girls at Ridgepark College, matriculating in higher-grade mathematics, for whom some form of tertiary education was not an option. In my opinion, and in South African terms, we can call these girls privileged. Leedy (1991) suggests that the sample should be carefully chosen and that through it the researcher would be able to see all the characteristics of the total population in the same relationship that they would be seen were the researcher to inspect the total population.

The school, Ridgepark College resides in the geographic and management zone called the North Durban Region, in Kwa-Zulu Natal, which requires that all research endeavours conducted in it's schools request permission. See Appendix 1 – for NDR notice No.15 of 2000. A letter of request was submitted to the Principal of the

school, the Governing Body, as well as to each of the parents of the girls that volunteered for the study, requesting permission to conduct the study and to involve the learners. Refer Appendix 2. Soon after, the autobiographical writing commenced, in March 2001. The 29 volunteers were given their journals and asked to provide me, with as detailed as possible, their autobiographies. To make them comfortable, I met them at a preliminary session first, in which I told them about myself and the experiences that had brought me to this point in my research. I told them what I had hoped to gain, the questions that I wanted to answer and how their participation would assist me as a professional and personally. I impressed on them the confidentiality of the exercise and that they were allowed to be anonymous if they wished. The girls were given 2 weeks in which to complete their assignment. I thought the time frame adequate, so as not to place these matric learners under undue stress. I had taught these learners for two years prior and was convinced of their ability in mathematics, as well as, their ability to express themselves well, spoken or in writing, so I knew they could produce rich qualitative data.

They complied admirably. I received 20 out of the 29 journals that I had originally handed out and many messages of support from parents. I was struck by the girls' openness and co-operation. Their writings exceeded all my expectations. Photographs, drawings and illustrations intermingled with the story to give as clear, as is possible, picture of their lives. In reading these journals I felt like a very privileged visitor into their personal and private space. I did not record how many times I thanked them.

I felt then a strong desire to probe more deeply their mathematical lives, so that this could run on a parallel canvas to their lives, and I followed up with a questionnaire. See Appendix 3. They were again given two weeks to complete this task. I was amazed when I received the journals again, how many of the girls treated their mathematical experiences as very separate from their life experiences. Now, with the parallel canvasses, a more explicit and total picture could unfold of the entire group. This data, the 20 autobiographies and 20 questionnaires, was categorised 'High, Middle, Low', in terms of the performance of the learner in classroom assessments and was analysed in chapter 5. The narrative analysis involved the examination the data sources from the five learners and appears in Chapter 6.

I felt compelled at the end of these narratives, their life and mathematical life stories having been told, to expand the literal and visual picture to include their voices. I also wanted to get a feel of their home environment. It was not practical to visit all 20 girls and I decided on selecting 5 from the group. I chose Gaylene, Fortunate, Robyn, Karushni, and Lynette to interview. The next page briefly profiles these girls.

Again, I looked at my criteria for diversity, explained earlier. I also chose girls who stood out, in their writings and in my classroom interactions with them. A semi-structured interview commenced. See the semi-structured interview schedule - Appendix 4. Participants recalled the interpretations of their experiences relating to their mathematical lives in and out of school. The interview helped to consolidate and elucidate much of what the learners had written. Also, I wanted to understand their growth and development in mathematics and to put a picture to the context that they had described. In addition, by the time of the interview the year had progressed to the point where all the participants had finalised their career/ study paths for next year. They had chosen. It was an opportunity to examine all influences past and present that had led them to these choices.

It has to be noted that all learners that were selected had very similar backgrounds in terms of previous primary education. Most attended previously Model C schools, which in the transformative context of South Africa schools, were fairly integrated, where learners were able to learn with others from other racial, ethnic and language backgrounds. All were totally fluent in English. I wish in no way to imply, that the learners are similar, their lives, experiences and interactions show their uniqueness as individuals. The table is an attempt to show where they were coming from and to have factual threads declared.

Profile of Females whose Autobiographies were Chosen

Learner	Gayleen	Fortunate	Robyn	Karushni	Lynette
Surname	Harris	Mhlaba	Brown	Naidoo	Mofokeng
Age	17	17	17	17	17
Race	white	african	coloured	indian	african
Residence	Greyville- own home	Clare Estate own home	Sydenham- own home	Reservoir Hills- own home	KwaMashu- own home
Sex	Female	Female	Female	Female	Female
Socio- Economic Status	Middle	Middle	Middle	Middle	Middle
Grade 11 Symbol in Math.	A	B	A	C	C
Secondary	Ridgepark	RidgePark	Ridgepark	Ridgepark	Ridgepark
First Language	English	isiZulu	English	English	isiZulu
Frequent Language of Home	English	IsiZulu/ English	English	English	IsiZulu/ English
Religion	Christian	Christian	Christian	Hindu	Christian
Position	2 nd child	1 st child	1 st child	3 rd child	3 rd child
Parents Career:	Engineer	Teacher	Teacher	Broker	Driver
Father/ Mother	Teacher	Teacher	Book- Keeper	---	Nurse

3.3.3.2 The Collection of Quantitative (Statistical) Data

To contextualize the qualitative data above, it became necessary to paint a macro quantitative picture against which to interpret the data. The statistical data was obtained from the relevant institutions, usually by telephonic request and conveniently e-mailed on the day. The University of Durban-Westville and the Department of Education required written formal requests indicating the intended purpose of the data before they could release information. Pertaining to matriculation results, except for 2000, the statistics desegregated for gender and race could not be obtained for the years 1997 to 1999. Both the regional and national governments could not make this information available. The regional department in particular, suffers a lack of a database of information concerning education and has to have all requests for information formalised as written requests to the relevant directors. Having complied with the bureaucratic requirements, this study had to proceed without reply from relevant directors. The National Department of Education was more forthcoming and information was received on the day requested, via e-mail. Professor Michael Kahn, education advisor to the Minister of Education at the time, kindly volunteered his tables and reports on the Matriculation Examination 2000 and acceded readily to all my requests for explanation or clarity via e-mail. I received no information from the Provincial Department of Education to date, despite my compliance.

The statistical trends, at Ridgepark College, those pertaining to all schools in the education department in the matric mathematics examination, and universities, regarding the participation, performance and career choice of females were examined. Pertaining to university mathematics, the gender-segregated statistics were obtained from the respective university administrations. The universities of Durban –Westville, Natal and South Africa participated. The University of Durban-Westville released the statistics of all B.Sc degrees that required a course in mathematics. The University of Natal was the very amenable to assisting research students and e-mailed the statistics on the day they were requested. They provided all degrees that required mathematics including the post-graduate degrees. UNISA was able only to release the participation (enrolment) statistics. The different ways in which the different tertiary institutions captured and presented their student data would have made the aggregating and

comparing of data across institutions problematic, had it been an intention of this study.

The purpose of the statistics was to illuminate the trends in mathematics degrees in terms of female participation and performance (Universities use the terms enrolment and graduate). The reader must be aware that the degrees across the institutions for which the statistics are offered are not standard. UNISA for example, offers statistics for mathematics in astronomy and none of the other universities offer astronomy. My request to universities was for statistics pertaining to mathematics, of the numbers of females involved in mathematics at that campus. A comparison of the throughput rates of the various campuses would not be feasible as the type and number of degrees that involve mathematics vary. It was my sole intention to gauge, the level of female participation and performance, in mathematics, at the universities and not to evoke an institutional comparison. To do so one would have to compare the equivalent B.Sc degrees in mathematics across the institutions. The data in this study does not allow that. The statistical data had as its intention to prepare a canvass of broad strokes, to elaborate a context, onto which to impose the data gleaned from the autobiographies. For instance, the statistical striations compelled analysis and comment along gender and race lines.

3.4. The Duality: Teacher and Researcher

This research study afforded me an encounter with my learner's lives outside of the mathematics classroom. The picture that developed of them through the analysis was therefore more holistic. It gave me deep insights into my context as a teacher at an all girls' school. I reflected on my practise and was able to be more critical of aspects that assist the learning and participation of girls in mathematics. Consequently, I could rethink my methodology for other learners I would still encounter. From my participants especially, and then the reading of research, I was compelled into finding some understanding that would inform my practice, I will draft for my department (learning area), at school, strategies that will give females a greater sense of participation in mathematics at school level, that could link to further study.

Of concern to me as a researcher, was that I had known and taught these girls for the last 3 years. We shared a bond that brought us closer than any other teacher in any other subject. My dedication to their understanding of the mathematics that I taught and their quest to make sense of what they learned means that we regularly sought each other out, during and even outside of the classroom contact time, school days as well as holidays. Samuels (1998) talked about creating in interactions with learners a 'kind of open critical discursive space' where they could freely produce comments (data) without fear of intimidation or repercussion. I mentioned earlier, that I could not understand that they could disclose of themselves to me as a researcher, and not as a teacher. This duality, of researcher and teacher, raised for me several concerns:

- *Would I be able to be sufficiently critical of the data that they provided?*
- *How would I react to them now as people and not just mathematics learners?*
- *How would the data they had provided infiltrate, to affect, my future interactions in the classroom with them?*
- *Also, I had to question how much of the separation that exists between teacher and learner had actually been bridged by the researcher?*
- *Were they free to disclose totally and to still find themselves in my classroom the next day, expecting no judgements from me?*
- *Did they disclose only what they thought, I would think, appropriate?*

South Africa, in it's developing context, with issues of gender redress a priority, needs that a variety of different contexts be assessed and a variety of different data collection strategies be employed. In the instance of this study, as the data unfolded, I saw that the reflective, autobiographical/narratives needed the personal contact of the interview. Vithal (1998) concurs that refocusing and alteration of data collection plans and research methodologies are endemic to researchers in a rapidly changing context. They contend that research in changing /developing contexts need to be validated so that the findings are usable by others that find themselves in the same contexts. Contexts that are undergoing transformation in their social, economic and educational contexts may pose the following disruptions to researchers:

1. *Access to schools may be restricted or not allowed* (Refer Departmental Circular – Appendix 1). This study was subjected to specific protocols before

it could commence. The permission of all stake holders, in this case the education department, principal and parents, had to be sought (Appendix 2).

2. *The subjects undergo evolutionary (if not radical) transformations of their own personalities, ideologies and beliefs. This means that the data is subject to a range of fluctuations.* The current South African, economic and political idiom resulted in girl's constantly revising study and work choices post matric.
3. *The subjective interpretations of research subjects alter significantly in relation to time, place and context during data collection.* Many of the girls that participated in this study, have moved on to their respective paths of tertiary study. All hold the view that school mathematics was perhaps not as difficult when compared to the complexities, volume and scope of university courses.
4. *Research subjects sometimes offer contradictory subjective interpretations of the same events.*
5. *There may be wide gaps between what research subjects actually say and what they do.* Many girls felt there were no restrictions on the way that they chose careers. Yet they all chose what research would call 'conventional female choices' in study path and career.

I was cognisant of the fact that all these points were applicable to this study. In a rapidly changing context such as ours, these girls are forced to make sense of competing ideologies, values and beliefs. Their involvement in the study forced them to confront issues on gender equity, political affiliation, social convention in career choice, and to challenge traditions that held sway in their homes. In many ways I felt that I had driven and initiated a transformation in each of them and they in turn in me. This was an atmosphere that was far from sanitised, we challenged preconceived givens, and our boundaries fluctuated. The data analysis will present these various levels of contradiction and conflict, variables that resisted configuring in our developing context.

In South Africa we need to discover the various realities that exist in any context. It was as important aim of this study that it presents the various dimensions of the enquiry in all its messiness. My learners in their feedback on this completed study will judge if they have been represented accurately. The reader of this research has to

decide the ideas that can best be adapted to his specific context. Within the naturalistic paradigm one has to discover the multiple realities that co-exist in the research context. I have aimed to present the in- depth, rich information, that is context specific and uniquely context - bound. I hope to provoke questions and develop ideas, rather than provide answers that one may ask of ones own context.

3.5 Limitations of the Study

The limited number of mathematics learners that were used as a sample to assert, support the findings of the study, could be identified as a limitation. However, it was the intention of this study to gain the understanding of an education phenomenon. The intention was to evoke discussion, to stimulate ideas, and for the readers of this study to take from what is needed for their particular circumstance.

Research of this nature comes with a large inferential component. I was able to use, only what the girls and bureaucracies were able to provide me. Many learners of the sample, were English Second Language learners, and often wrote the way they were thinking. I have attempted as best as I could to represent their dialogue and derive understanding from it. I could only disclose and publish what they had allowed me to.

I would have preferred that once this study was complete, that my co-authors (my sample of 20) could have had opinion (criticism or verification) on my representation of the data they provided and the conclusions that I had drawn. This was not possible as the study concluded when they had already completed school. It is hoped though, that the study presented sufficient triangulation, with data from the school and universities.

3.6 Orientation to Analysing the Data

In the next three chapters that follow, I examine how the participants inter-relate with each other and their context, as well as, how the various instruments inter-relate. In the analysing, it was hoped the learners narratives (journals and interviews) collected

over the period of the year could be deconstructed to their component parts and the interconnectedness or polarity between the different aspects can be exposed.

The data subjected to scrutiny has been categorised as primary and secondary sources. The primary data: autobiographies/narratives, questionnaires and interviews provided a direct link into female learner thinking and the rationale for their mathematical choices. The group of 20 learner responses were then represented in categories High, Middle and Low, in chapter 5, made on the basis of their classroom-based assessments. The statistical information, in chapter 4, on the matric mathematics examination, statistics from the school, statistics from the universities, all the quantitative sources, provided a means of contextualizing the data from the qualitative sources by placing these girls first, in the context of schools statistical trends and second, in the mathematical world of the wider society. An analysis of the autobiographies of 5 girls and myself follows in chapter 6. Here themes that affect and effect female participation and choice in mathematics are described, discussed and deepened.

Perhaps the greatest challenge of this study was dealing with the feelings and emotional lives of my learners and the treating of this, as data. The contradiction arose, for me, since the Mathematics classroom is mostly bereft of emotion and humanness. I learned differently. It required that I harness skills that were infrequently called on in my classroom practice.

Chapter Four - Analysis

To behold is to look beyond the fact; to observe, to go beyond the observation. Look at a world of men and women, and you are overwhelmed by what you see; Select from that mass of humanity a wee-chosen few, and these observe with insight, and they will tell you more than all the multitudes together. This is the way we must learn: by sampling judiciously, by looking intently with the inward eye. Then, from these few that you behold, tell us what you see to be the truth.

LEEDY, 1991

4.1 Placing the Analyses in Context

I have taken the data in this study and subjected it to analysis in three parts that form the next three chapters.

Chapter 4, looks at what the statistics show, of the participation and performance trends in mathematics on the senior certificate examination, of the participation and performance trends at Ridgepark College and finally the participation, performance and choice trends at university (that lead to career choice). This study found that disparities in performance, participation and choice in mathematics occur along the lines of gender and race. It sought to understand this position and with the result, particularly the statistical data, has been segregated along these lines, to enable clarity and to reveal the actual picture, to you the reader.

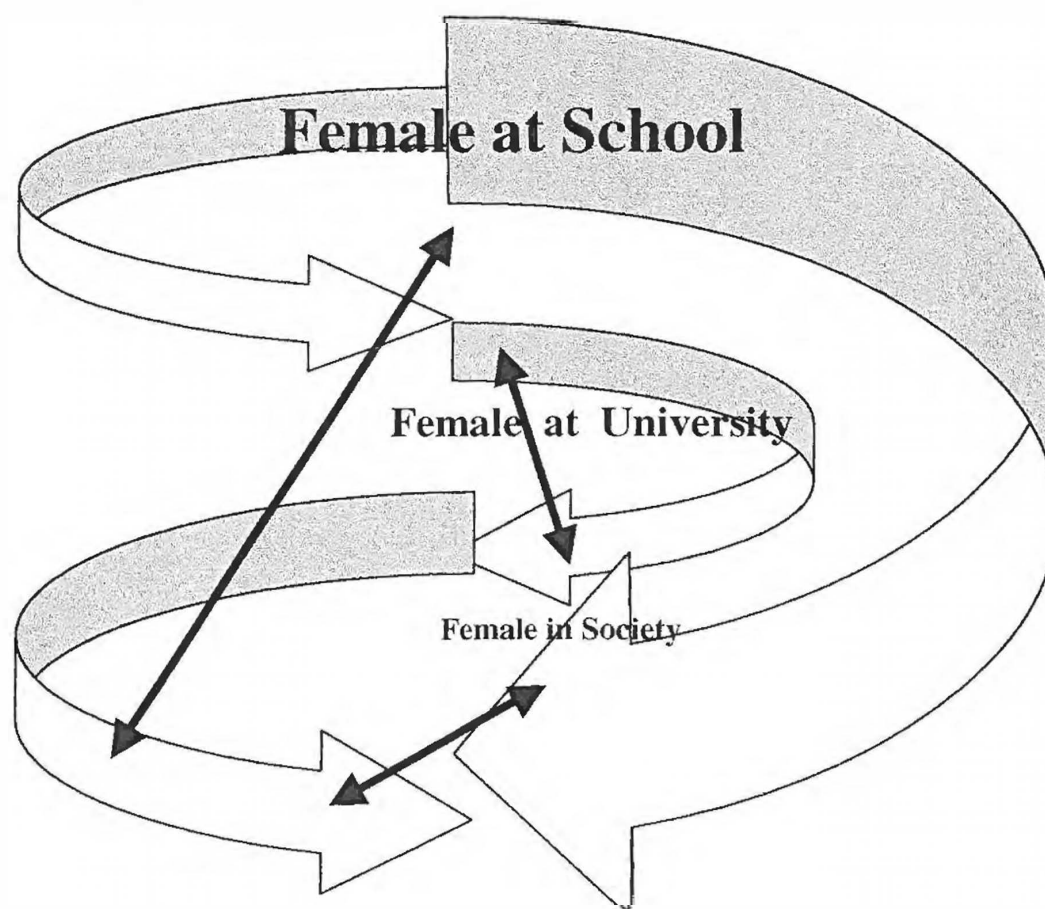
Chapter 5 will examine the autobiographical narratives and questionnaire responses of the 20 learners in the group, against the statistical bed that has already been prepared. The composite of their responses have been categorised and will be subjected to comment and analysis. Here we will examine how these girls regard their participation and performance in mathematics and how they exercise choice in mathematics. Keep in mind that they exist, influence or are influenced by the statistical landscape that is already established.

Chapter 6 examines, at a more intense and deeper level, the detailed stories/narratives of 5 females from this group and myself, who are 'successful' in mathematics. I have included my story as a successful girl in mathematics as an initiator on two levels:

The first is that I wanted to relate and relay my experiences in mathematics, as a learner, to the girls. The second level's intent was to interrogate the impact of my experiences on them, now, as their teacher, who chose to study mathematics further, and on myself in the duality of researcher/ teacher. 'Successful', in terms of the girls, being defined as passing school/classroom based assessments with an average of 60% or above. In terms of myself their teacher, I would consider success as being a distinction student at matric level and university mathematics major. Issues that emerge from these stories will be expanded and synthesised into themes with emphasis on South African female, participation, performance and choice in mathematics.

The analysis on these three levels served to re-emphasise the concept of the helix, illustrated below, in which I see multiple threads that are linked and connected, like those in the DNA molecule. There are multiple connections that provide a diverse, varied and multi-dimensional truth. Chapter 4, the examination of statistics, would have been only a partial truth, without the other threads.

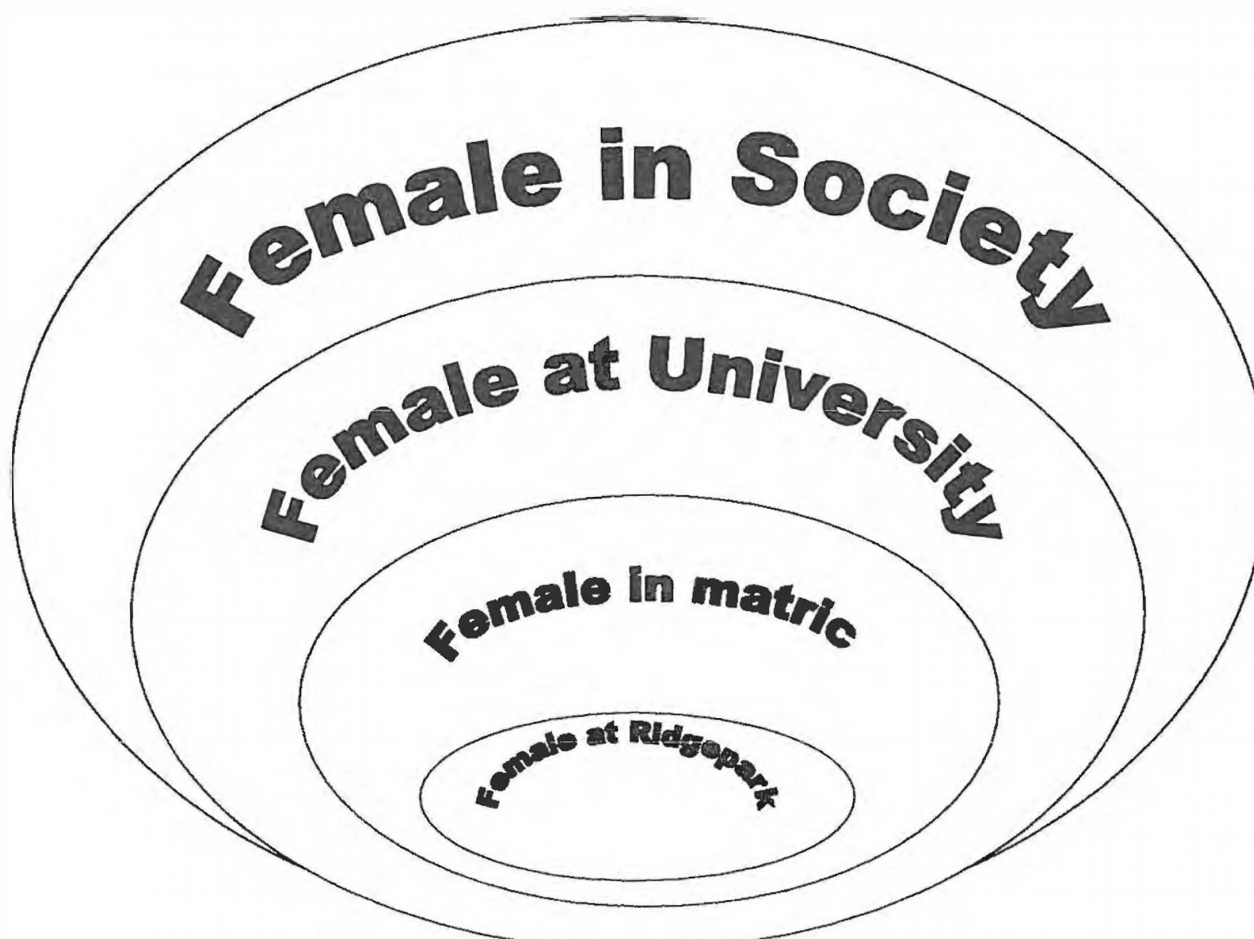
Graphic 1: The Helical Representation of Female Participation in Mathematics



The diagram that follows, illustrates the levels, of female participation, performance and choice, in mathematics, that exists, and was discussed in this analysis. The circular nature that I have assigned, intimates at the way that pressure is exerted towards the centre. It hints at the outside pressure or influence that a female at Ridgepark College must feel with her involvement in mathematics at present. It suggests that energy/effort is involved to move outward to the next level. Just looking at the diagram, one feels this tension; your eyes feel the pressure towards the centre.

The size and boldness of the font chosen, also serve to portray this pressurising and inhibiting trend. Females experience these competing tensions, in very tangible ways at the various stages of their mathematical lives, as Chapters 5 and 6 will show. These are the dynamics that operate on the helix above and, in addition, exert influence on the statistical outcomes discussed in this chapter. This is a diagrammatic representation, of how I see the various parts with and within each other, revealing their co-dependencies and tensions.

Graphic2: The Dynamic Tensions of Female Participation



4.2 Orientation of this Component

Matric Mathematics - Participation and Performance Trends

In this section, we look at the participation and performance trends in the senior certificate mathematics examination. They provide a backdrop for the discussion later, on the participation and performance, in mathematics, of the girls at Ridgepark College, in general and then the selected girls at Ridgepark College around who, this study has evolved. I have broken up this analysis into two parts:

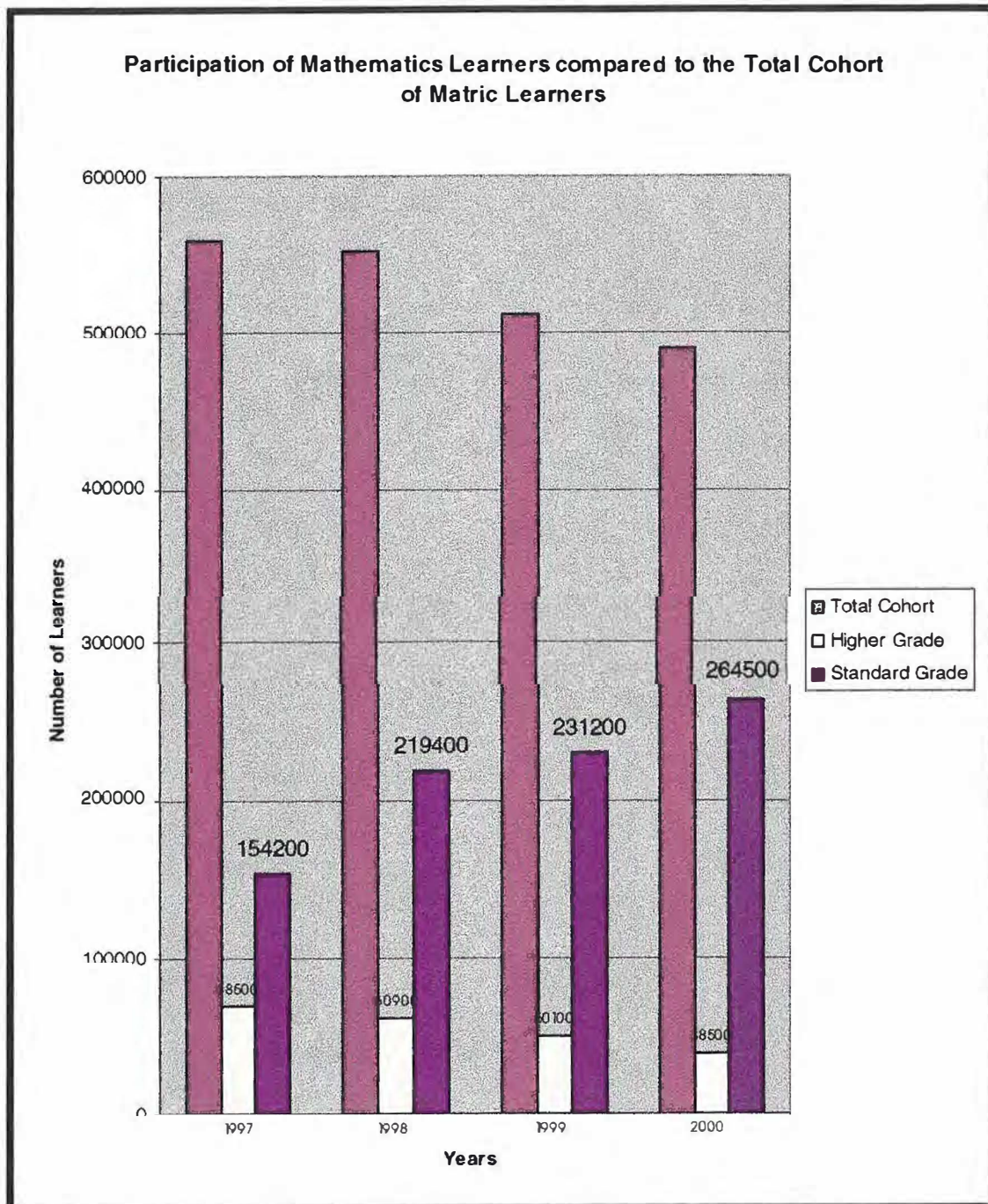
- 4.2.1 An examination of national and provincial statistics, in mathematics, for 1997-2000.
- 4.2.2 The gendered, participation and performance trends, in the Senior Certificate Examination 2000. African Learners only.

4.2.1 Matric Mathematics - Participation and Performance- 1997-2000. Nationally and Provincially.

This analysis shows the number of higher-grade students in mathematics compared both, to the number of standard grade students as well as, to the total cohort of matriculation entries. It places higher-grade mathematics, as well as, the girls in this study in a more complete picture of all matriculation entries. We can further, ask questions on the status of mathematics in terms of, the number of learners that have participated in mathematics in the last four years. The trends in matriculation enrolment alone raise questions that have great social, political and economic implications for our province of Kwa- Zulu Natal and our country, South Africa at large. Concurrently they raise issues on the future of mathematics as a subject at school and tertiary level. Recall definitions elaborated earlier: 'Participation', in this study, refers to the number of learners that have written the examination, which does not necessarily equate the number of learners that have registered for the examination. 'Performance', in this study, refers to the learners/ students that pass/graduate in a particular mathematics course. And 'success', in this study usually pertained to learners/students who were performing well at higher-grade mathematics. At school

level, this meant that their assessments were usually above 60% or a C (the main criteria for the selection of the core sample of five learners).

The Status of Mathematics Nationally, in terms of, Participation



Graph 1.

(Source: Statistics supplied by National Department of Education, Pretoria, 2001)

This 'global' picture of mathematics in the context of the Matriculation Examination, 1997 to 2000, South Africa's only exit examination after 12 years of formal schooling, provides a very disturbing picture. Fewer learners are matriculating, if we examine the falling 'Total Cohort' columns, and, even fewer are participating in Higher Grade Mathematics over the last 4 years, if we examine the diminishing and comparatively lower, columns of 'Higher Grade'. The declining trend of the yellow columns, where the diminishing trend of higher-grade participation, in mathematics, is reflected as percentages, correlates directly with the last line of the table. The numbers, on higher grade, have decreased from 68 500 in higher-grade mathematics, in 1997, to 38 500, in 2000. A decrease of 56,2% of students involved in higher-grade mathematics, that is, the number more than halved, in the space of 4 years. In the matriculation examination 2000, only 8% of the total learners were doing mathematics on the Higher Grade. The implications, reserving direct consequence to this study, are that fewer learners, and even fewer females are eligible for entry into mathematics and mathematics related degrees and consequently, the prospect of higher paying jobs. Thus, not facilitating access for women into traditionally, male dominant, high status professions, for which a pass on the Higher Grade is a requirement.

Table 1

Mathematics Participation Trends				
	1997	1998	1999	2000
Higher Grade	68500	60900	50100	38500
Standard Grade	154200	219400	231200	264500
Total Math. Learners	222700	280300	281300	303000
Total Learners in Matric. Cohort	559233	552862	511474	489941
%Participation - HG&SG of Cohort	40%	51%	55%	62%
%Participation - HG of Math. Cohort	31%	22%	18%	13%
%Participation - HG of Total Cohort	12%	11%	10%	8%

Source: Department of Education (2001a) ⁴

⁴ The original table, from the Department of Education (2001), has been adapted for the purposes of this study, to include the last three highlighted lines that show special relevance to this study.

Any person viewing this table would be excused for feeling optimistic after looking at the grey line, that compares the percentage of higher grade and standard grade mathematics learners with the entire cohort: *mathematics participation is improving*. But, in a very theatrical sense, 'all is not as it seems'. The escalation of the standard grade mathematics numbers, have to be examined in conjunction with the declining higher grade numbers and can be attributed to many learners 'switching grades' from Higher to Standard as a result of poor performance. This tendency reveals itself, by falsely inflating the 'percentage Participation of Mathematics learners in the examination', to 62%. I say 'falsely', because learners do not choose to do mathematics on the standard grade, initially, at grade 10 level. In general and traditionally, grades change from higher to standard as a result of poor performance at the end of grade 10, where the learner fails to attain a summative assessment of above 40%. The number of learners registering for the matriculation examination is declining, consequently, mathematics learners, on the higher grade, are declining, the increase reflected at 62% is due to the increase in standard grade numbers, and which this study reiterates, can be due to the movement from higher grade to standard grade. The practice of 'grade switching', particularly among learners consistently scoring in the range 30 to 40 percent in class assessments, is frequently encouraged by schools so that schools, particularly the more advantaged, with good results track records and higher pupil participation, can reflect a good mathematics pass statistic. In summary, Mathematics Higher Grade participation is declining. If tertiary study in mathematics and mathematics-related courses are a goal and valued for economic and social upliftment of our workforce, then, the consistent downward trend in higher-grade mathematics participation will not contribute to achieving this.

Graphs 2 and 3 that follow, look specifically at the national higher-grade and standard-grade, mathematics participation and performance picture. This is mathematics purely, without the combination of science. Compared to Graph 1, page 69, which examines mathematics against the total cohort of matriculation learners, graphs 2 and 3, provide the contrast of participation against performance in mathematics specifically. I say 'contrast', as both graphs 2 and 3, reveal that too few learners pass (perform) in mathematics as compared to the numbers that participate.

The pass rates of both grades, higher and standard, are very low and demand attention.

Graph 2.

(LearnersX1000)

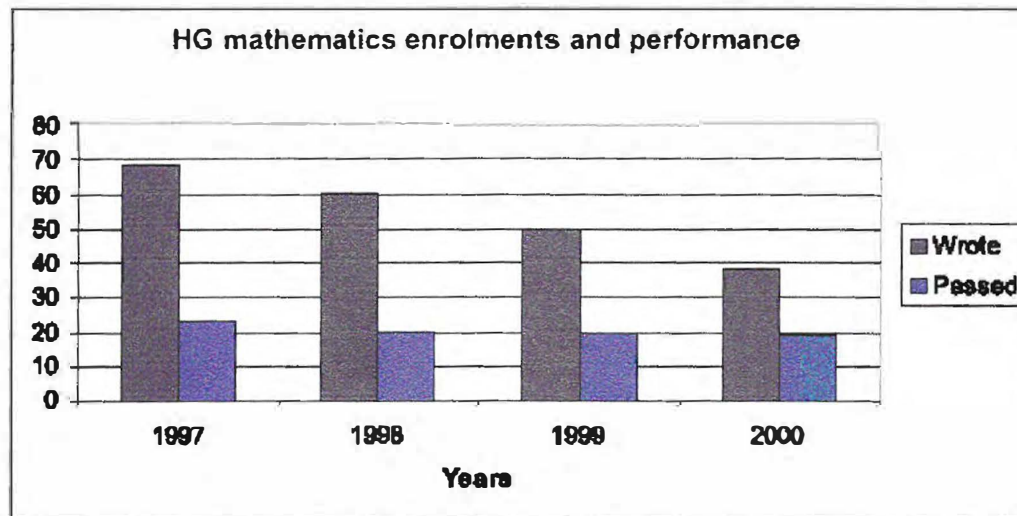


Figure 2: Higher Grade Senior Certificate mathematics participation and performance

Source: Department of Education (2001a)

Graph 3

(Learners X 1000)

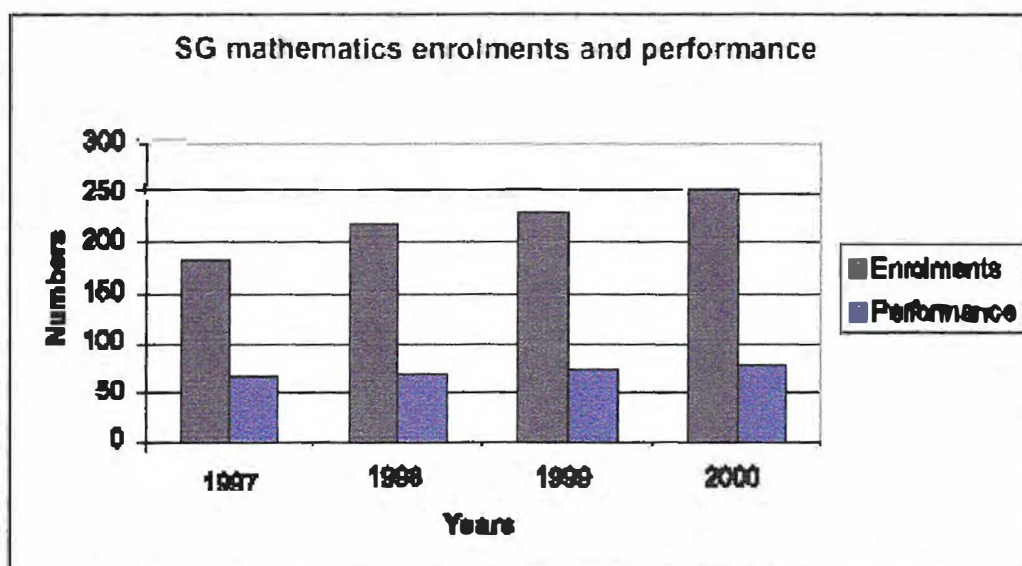


Figure 4: Standard Grade Senior Certificate mathematics participation and performance

Source: Department of Education (2001a)

Graph 2 shows that the higher-grade candidates, in mathematics, the participation levels, have decreased in the last four years. The number of higher-grade passes, that is the levels of performance, has remained about consistent. There has been no increase in the levels of performance. Graph 3 shows that the number of learners, on the standard grade, is increasing. The pass rate appears consistent, with no significant improvement. On both graphs 2 and 3, when taken as a percentage of participation, the performance, remains unsatisfactory. Pertaining to Graph 2 particularly, the decrease in participation (enrolments) in higher grade, mathematics, spells the concurrent decrease in female participation, a focus of this study.

4.2.1.1 The Mathematics Deficiency Syndrome

Table 1 discussed previously, showed a decrease in the number of learners in mathematics, participating in the matriculation examination, nationally, in the last four years. It serves to support graph 4 below that shows the numbers of mathematics and science learners, as a combination, is also decreasing. Mathematics and Science being the gateway subjects for enrolment into tertiary study. With this in mind, the combined participation in Mathematics and Science, had to be examined.

Graph 4

(No. of learners multiplied by 1000)

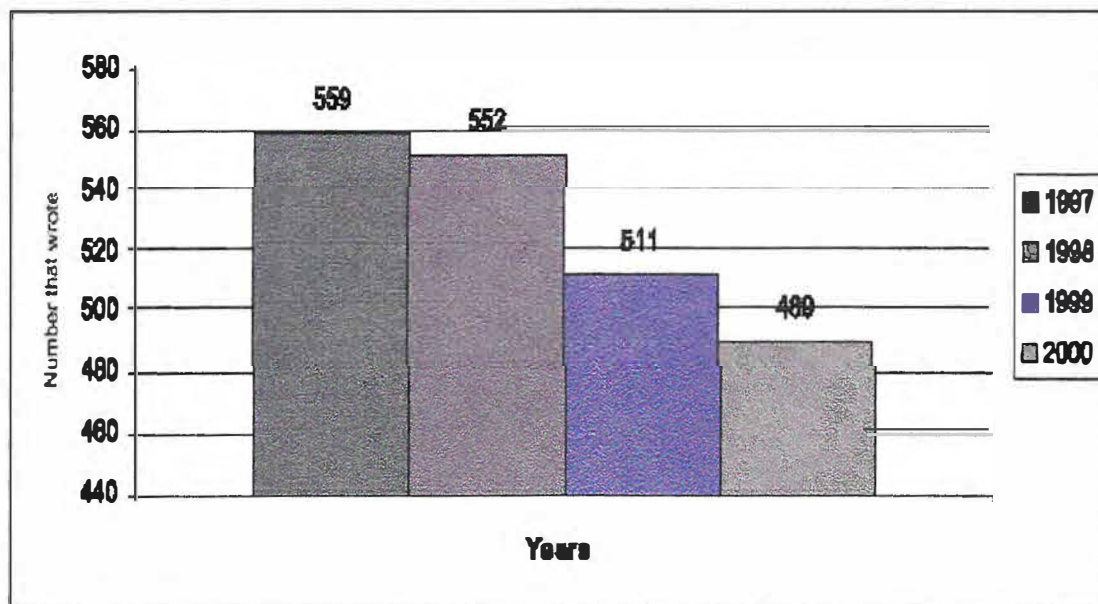


Figure 1: Senior Certificate enrolments for the period 1997-2000

Source: Department of Education (2001a).

Graph 4 above, shows clearly that the number of mathematics and science learners, as a combination, is declining, in the matriculation examination.

Mathematics and Physical Science, as already mentioned, are the 'gateway' subjects to mathematics related study fields. In combination, a pass in mathematics and science is usually a criterion for students to enter mathematics and science-related degrees. Table 2 below, reveals the diminishing pool of matriculants, in percentage form, that are eligible for mathematics and science degrees at tertiary level.

Table 2

Dept. Education (2000d)

Participation and Performance in Maths and Physical Sc.																	
The Total Number of Candidates(X1000)		Grade	1997				1998				1999				2000		
			559,0				552,0				511,0				489,9		
			Wrote	Pass	%		Wrote	Pass	%		Wrote	Pass	%		Wrote	Pass	%
Mathematics	Hg	68,5	22,8	4,1		60,9	20,3	3,7		50,1	18,8	3,8		38,5	18,3	3,8	
Mathematics	Sg	154,2	66,9	12		219,4	68,6	12,4		231,2	72,2	14,1		254,5	79,6	16,2	
Physical Sc.	Hg	76,1	27,0	4,8		73,9	26,7	4,8		66,5	24,2	4,7		55,7	23,3	4,7	
Physical Sc.	Sg	85,2	35,2	8,3		83,8	43,2	7,8		83,5	44,0	8,8		125,1	55	11,2	

The table shows unsatisfactory performance in mathematics and physical science as a combination, if we examine the percentage pass. In mathematics, the highest percentage pass over four years, on the higher grade, was 4.1% in 1997 and in physical science, higher grade, 4.8% two years ago. Both, mathematics and physical science, higher grade, show desperately low and diminishing pass rates. The pass rates on the higher grade, for mathematics and physical science, are consistently below 5% over the four year period. The number of passes is incredibly low, the consequent number of females passing must be even lower, as these figures represent males and females combined. The standard grade figures are provided to emphasise the poor pass rate, that few students involved in mathematics and science at school will be deemed as acceptable for study in mathematics and science fields at university level. Consider that of the entire group, the female subset is even lower.

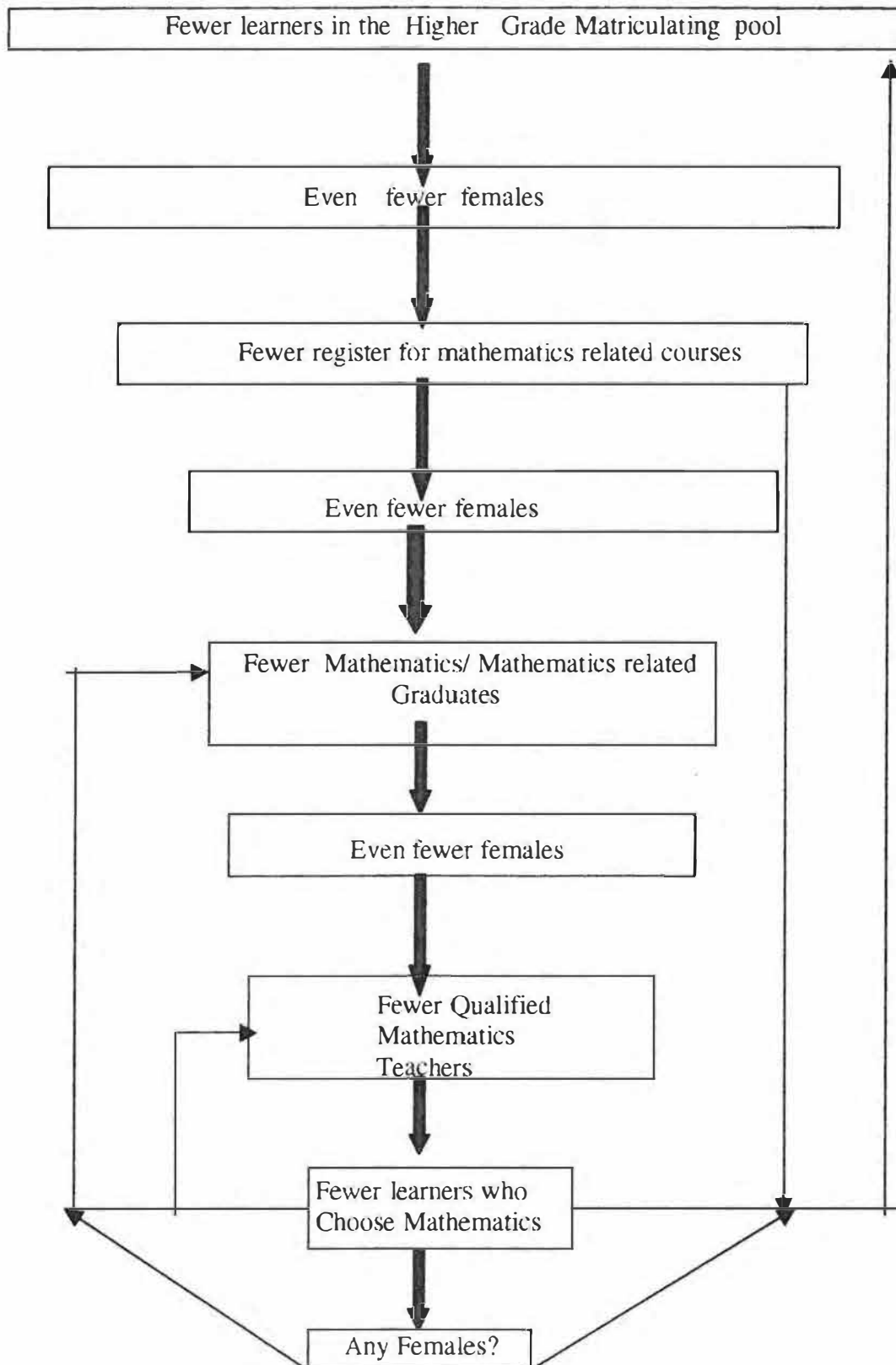
These pass rates have many implications. If we just concentrate on mathematics, the low level of performance in mathematics, higher grade, and impacts on, the provision and availability of skilled and competent teachers in mathematics, the future of mathematics as a discipline/subject, the funding that universities and tertiary

institutions allocate to the study of and research in mathematics. Would mathematics eventually suffer the cruel death of rarely being touched by women? Presently, those few that excel in mathematics are lured by science related careers that are more lucrative options in terms of incentives, and financial rewards. Teacher training programmes are resultant non-options. EduSource (1997) found that most mathematics teachers are not qualified to teach mathematics: of the 85% of professionally qualified mathematics educators, only 50% specialised in mathematics. The South African Institution for Race Relations (1998) found that a third of mathematics teachers had less than two years teaching experience. It further states that schools will begin to show a lack of mathematical expertise in terms of teachers and that this will bear out in the results that are produced. Pretorius (2001) in her report, 'Corporate Spending on Education', noted that, residential universities collectively produce about 160 mathematics and science graduates a year. Further, that at Wits University in 2001, only 8 mathematics and 10 science teachers will graduate. It is therefore not surprising that South Africa has a critical shortage of intellectual capital in mathematics and the sciences. There are many economic, social and political factors (hence I have called this phenomenon a syndrome), the availability of resources being one crucial aspect that contributes to the deficiencies in mathematics and science that we have seen. These in turn impact on the work force, where few females will be able to enter mathematics related fields.

The organogram below organises this cycle of diminishing mathematics participation and performance for females, as I see it. It has serious implications for the future of the subject, teacher training, pedagogy and political (pertaining largely to race) and economic (pertaining largely to race and gender) equity. The very apparent non-participation and the appalling under-performance of females, will manifest itself in many different ways. All at the end, unfortunately, threatening and depleting the formation of this country's core of competent mathematics and science expertise. To address gender imbalances within this context becomes all the more urgent. Perhaps it is time to address mathematics education from a different perspective, our current practices are clearly deficient.

Graphic3

My Mathematics- Deficiency -Syndrome (MDS) Organogram



- We observe a very steep downward/ diminishing education pyramid.

4.2.2 Race and Gender: Matric Examination 2000. African Learners.

The statistics below are segregated along gender lines for the year 2000 and representative of learners that also study an African language. It can safely be assumed that Black students predominantly, study an African language. That, while other race groups may study African languages their numbers are negligible compared to the majority grouping. The trends along all 9 provinces for the year 2000 are powerful enough to make a convincing argument for redress when it comes to gender and race participation and performance in mathematics and my opinion, should have major impact on the allocation of funding, entrance criteria for tertiary study and bridging or developmental programmes in mathematics. What I perceive as exceptions will also be discussed below. I have highlighted and chosen Kwa -Zulu Natal as the focus of the study, as the school and learners where this study is based is in this province.

Gender 2000										
Matric Mathematics 2000 - Higher Grade - African Learners only										
Province	Total	Male	Female	Male				Female		
				Pass	Converted Pass	Fail	% Pass	Pass	Converted Pass	Fail
WC	78	47	31	14	13	20	30	7	10	14
NC	12	9	3	7	1	1	78	2	0	1
FS	471	322	149	85	64	173	26	30	16	103
EC	332	219	143	76	39	104	35	37	23	88
KZN	572	3176	2536	521	579	2076	16	225	332	2019
MP	1331	849	532	137	149	553	16	22	61	449
NP	770	4184	3336	743	679	2762	18	238	332	2336
GAU	812	502	310	203	105	194	40	126	53	131

Table 3

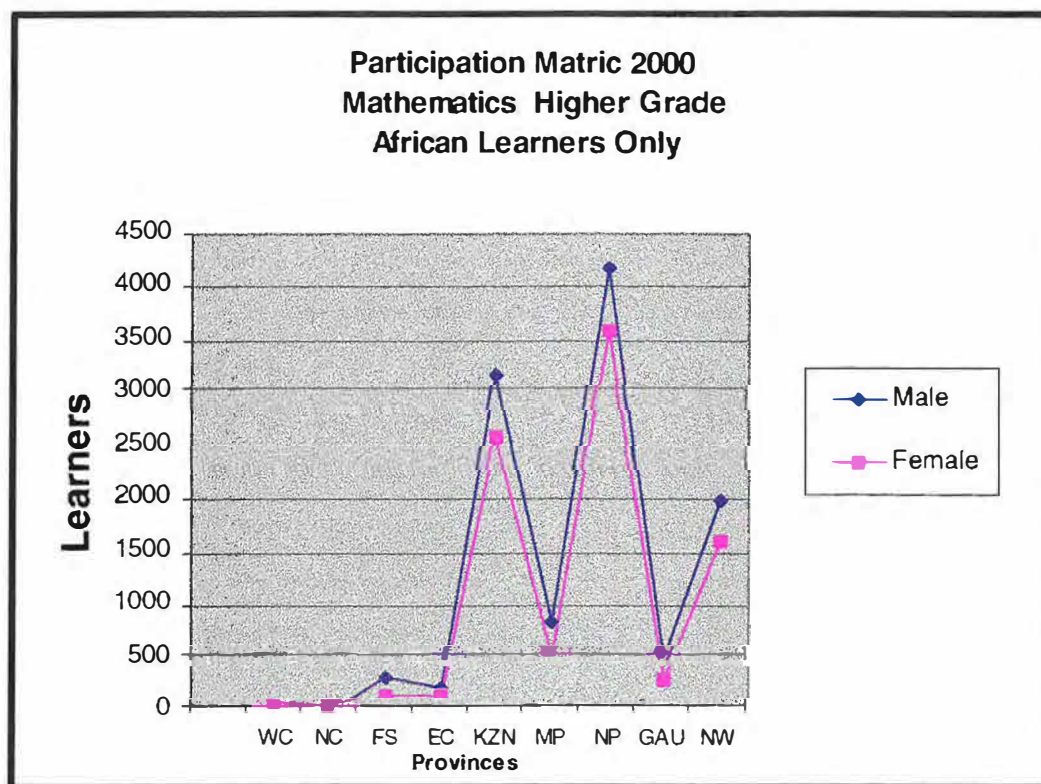
Provinces: Western Cape, Northern Cape, Free State, Eastern Cape, KwaZulu Natal, Maphumulanga, Northern Province, Gauteng, North West.

Source: Kahn (2001)

We observe at the outset, that higher-grade pool becomes even smaller in the case of black Africans who obtained passes in mathematics. The 2000 Senior Certificate results indicate that out of a total of 400 000, only 20 243(5,1%) Black African candidates wrote mathematics on the higher-grade and of these, 3 128(0,8%) passed. From the table, the number of African females that passed is even lower and is predominantly, below that of males. In addition, only about 900 African students achieved a C symbol or above (Department of Education, 2001d). Clearly the majority of learners in this country are matriculating without minimum requirements for admission into university faculties of engineering and science. This will likely create a bottleneck in the supply of black professionals and can be regarded as one of the greatest threats to the development of a skills based economy in SA. At provincial level, most of the black matriculants with higher-grade mathematics and science passes originated in KwaZulu Natal, namely, 746. The comparison of participation and performance rates of African males and females in mathematics are illustrated graphically and follow. Visually the graphs are able to establish the participation and performance level contrasts between African, male and female.

Graph 5

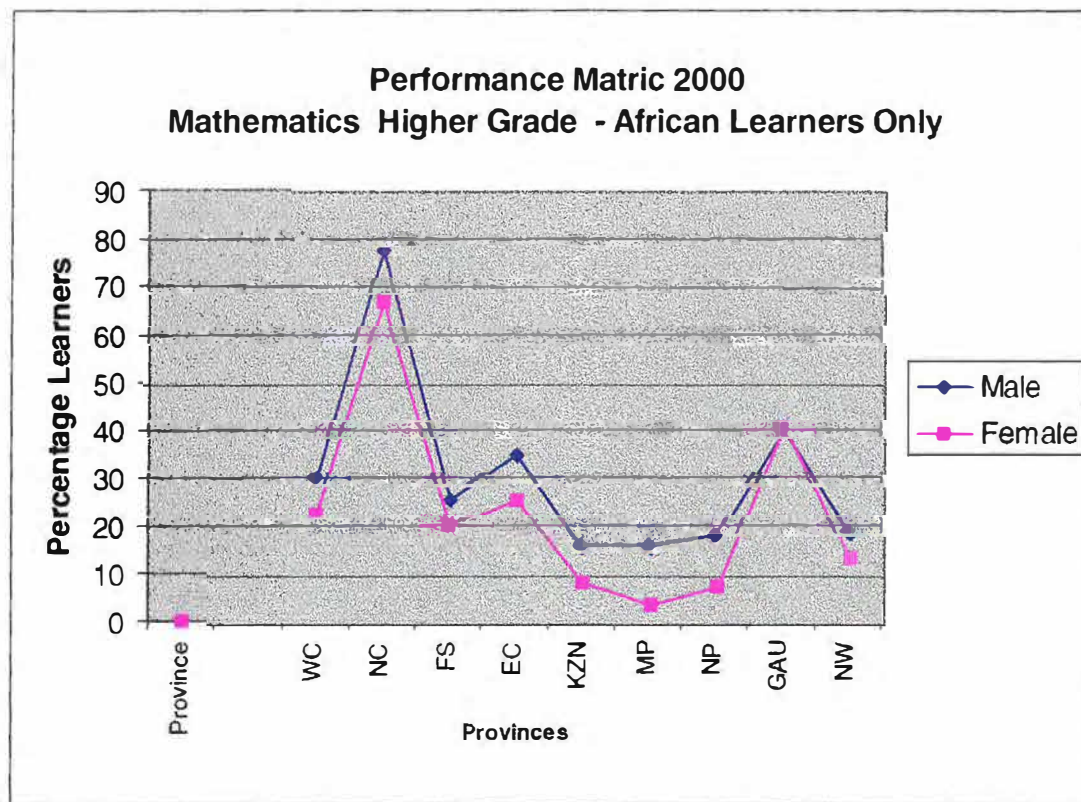
Source: Kahn, M(2001)



The graph shows that fewer African females (on the pink line) are choosing mathematics when compared to males (blue line).

Graph 6

Source: Kahn (2001)



African females are at a lower level of performance generally, when compared to males (indicated by the pink line that is consistently lower than the black). Overview of the 2000 exam results shows that passes in higher-grade mathematics has declined despite the increase in the overall matriculation result by 9%. There was a decline in the mathematics pass rate from 19,8% to 19,3% (from table).

When I first encountered the statistics from which the table and graphs above arose, I was certain that there had to be an error. The figures reflecting higher grade passes were far too low provincially and myself and colleagues, with whom I had consulted, were equally convinced, that these did not make sense. Try as I might, I just was not able to find plausible explanations to them. On consulting my source, I was reminded, that these were results for students that take African languages. That, we can correctly assume that most Africans, take an African language and that most non-Africans do not. I was assured again, that the figures were good to 5%. “Even if the WC is out by 100%, it is still a scandal”, was Professor Michael Kahn’s closing statement (personal communication, 2001). The pass rates of our African learners in mathematics seem too incongruous to be true. We as teachers of mathematics are

seldom exposed to a complete picture. This is a shocking reality. To address African learners in higher-grade mathematics and then higher-grade African females in mathematics requires a full attack in terms of policy, resources and practice.

The general trend is that males out-number females in participation and performance over all provinces. All provinces compared, KZN had the third lowest pass rate for females 225/ 2595 or 8,67%. About 91% of all females that wrote mathematics higher grade failed. Can we predict a dramatic change this year 2001? Have we intervened and changed much since last year? If not, then, only 1 out of every 10 girls on higher-grade mathematics will pass!

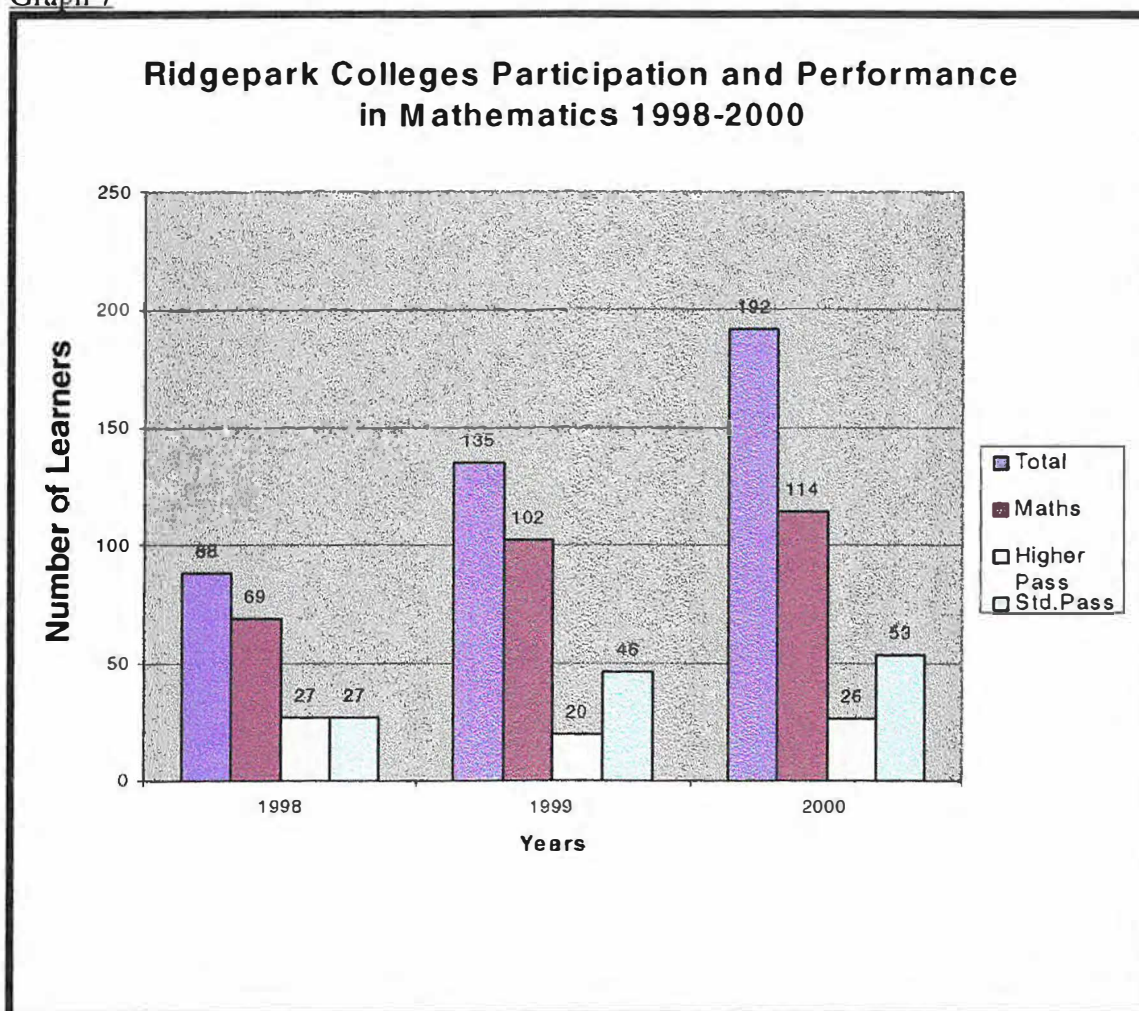
Due to its extremely low entry numbers in the examination, compared to the rest of the sample, the Northern Cape boasted the highest pass rates and therefore cannot be regarded as an accurate part of the rest of the sample. It shows a limitation of a pure statistical analysis. Simply put, a school with 5 higher grade learners, where all pass can boast a 100% pass rate and cannot be compared to a school with 100 learners where the chances that all will pass on the higher grade, are statistically less. As already mentioned, many learners are encouraged to switch grades so that the overall higher-grade pass in mathematics can be reflected more positively. Certainly, in my experience, Grade 11 higher grade final examination papers are set so that only those that are sure of passing on the higher grade do so, and those that are experiencing difficulty are then advised strongly on the basis of their unsatisfactory score, to switch grades. The exception in 'Participation' for Gauteng where females out-numbered males, can be explained because of this as fewer females initially participated and the performance percentage is enhanced. This would explain the one exception on the graph. In summary, the graphs show that, fewer females are performing (passing) in mathematics than males and consequently, fewer are entering mathematics related professions.

How does the school where the study is based fit into the national and provincial trends?

4.2.3 Participation and Performance Trends of Ridgepark College 1998-2000

Ridgepark College is an all –girl’s school, situated in Overport, Durban. It was previously Model C. By South African school standards, in terms of resources, it would be termed, advantaged. 90% of the girls do not reside in the area that surrounds the school. They commute to school from suburbs outside of Overport with the majority, more than 70%, of learners residing in townships Umlazi, Kwa Mashu and Ntuzuma. The total school population stands in the region of 1100-1200 learners over the last four years. The majority of learners, slightly over 70% are African. I was curious to see how my girls fitted into the dismal performance patterns of females in the matriculation examination, nationally, and more especially, to rate their levels of performance next to the dismal performance trend discussed earlier pertaining to African learners.

Graph 7



Source: Ridgepark College(2001)

To clarify the legend: 'Total' refers to the number of girls, mathematics and non-mathematics, registered for the matric examination; 'Maths' refers to the total of mathematics learners, Higher and Standard Grades combined, participating in mathematics; 'Higher Pass' refers to the number of girls that have passed/ performed on the Higher Grade; 'Std.Pass' refers to the number of girls that have passed/ performed on the Standard Grade.

The levels of participation, at Ridgepark College, in mathematics is dropping: 78% in 1998, to 75% in 1999, to 59% in 2000, when I compare the number of learners participating in mathematics, with the total school complement. This means that the number of learners choosing to be involved with mathematics is on the decline. This, despite the number of learners in matric, increasing. The number of standard grade passes (the blue bars) is increasing. The number of higher-grade passes has remained consistent and very poor. In 1998, 39% of mathematics learners passed on the higher grade when compared to the total maths learners; in 1999, 20% and in 2000, 23% of mathematics learners passed mathematics on the higher grade. This can be compared to the pass rate of African females in KZN, which I showed earlier to stand at 8,87%. The number of learners that failed moved from 15 in 1998; to 36 in 1999; to 35 in 2000. This was calculated by subtracting the higher and standard grade passes from the number of mathematics learners. Confirming provincial and national trends of unsatisfactory pass rates, i.e. declining performance among females. The national pass rates for mathematics, higher grade were 3,7%, 3,8% and 3,8% for 1998 to 2000 (See table –Mathematics Deficiency Syndrome). It would be a calculated guess, but I feel that the pass rates for females particularly, would be much lower. While we, at Ridgepark College, do have pass rates that are higher than the national norms, the performance rates in mathematics are unsatisfactory.

Of interest was also, the decline in the number of learners choosing mathematics. All learners do mathematics up to grade 9. In 1998 - 19 females, in 1999 - 33 females and in 2000 - 78 females were not doing mathematics in Grade 12 (total learners minus the mathematics learners). They could only have chose to leave mathematics at the beginning of grade 10. Why are so many learners opting out of mathematics, after grade 9? I am aware that the school's guidance and counselling department has become more aggressive in dissuading girls who are performing poorly in

mathematics from choosing mathematics. Also, the number of subject packages, that exclude mathematics, and still enable a learner to achieve a matriculation exemption have increased. These options were instituted by the school to maintain its high pass rate in matric as it was felt that poor results in mathematics, in combination with other weaker subjects, often contributed to many weaker learners failing to meet matriculation exemption criteria.

The lowered participation of girls in mathematics can be attributed to two factors, in my opinion: the first, being, that girls no longer deem participation in mathematics as important as people previously had. This I have gauged from learners who have opted out of mathematics over the past few years. The usual feeling is that they can take another subject and be assured of passing, whereas in mathematics this pass is not guaranteed. The second is that many learners who are not performing well in mathematics in grade 9, usually with a year mark under 40%, are persuaded, to choose subject packages that do not contain mathematics i.e. they are ushered out of mathematics by teachers and counsellors.

Yet, I maintain as my credo, that all females can learn mathematics. I feel that those that persist with mathematics receive a sense of fulfilment and empowerment, that is recognised, if not at all times, rewarded, by society. Once these girls at Ridgepark College have matriculated, my experience has been, that the majority of learners choose universities that are close to home. Universities that are urban (as opposed to others where they may have to consider resident costs), are of good repute, are accessible by public transport and offer a variety of recognised courses that are usually chosen by the girls. The most popular choices being the University of Durban-Westville(UDW), the University of Natal –Durban(UND) and the University of South Africa(Unisa).

The next section examines participation and performance trends in mathematics at these universities and develops further, on the choices that females make, in mathematics, at these institutions. The universities of Natal and Durban – Westville sent complete statistics involving student's participation and performance, segregated according to race and gender. These have been tabulated and presented in Appendix 6. Different universities use different systems for data capture so it was not possible

to get similarly disaggregated data. A combined UDW and UND, concise version, segregated according to gender, specifically, is presented as Tables 4 and 5, in the section that follows and is illustrated graphically. Unisa could only make their participation statistics available. For details of the degrees that were involved in the construction of these tables see Appendix 6. To reiterate, the intention of the graphs and tables that follow, is not to invoke an institutional comparison but to provide the broad-brush strokes for a gender comparison.

4.2.4 Participation and Performance Trends at Universities

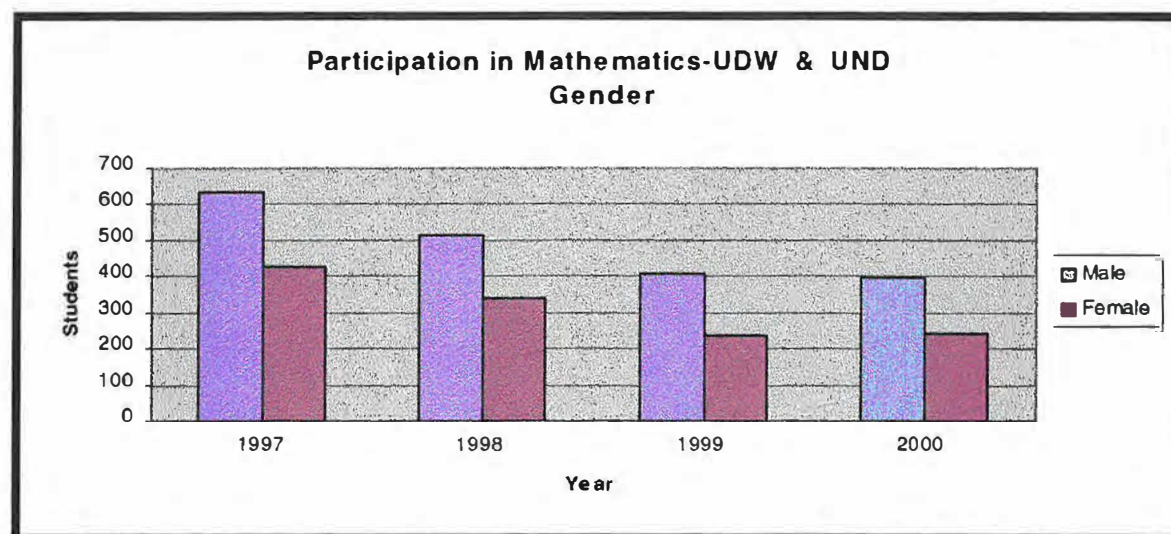
Table 4 UDW,UND (2001)

UDW and UND Participation		
Year	Male	Female
1997	635	426
1998	514	342
1999	408	238
2000	398	243

Table 5 UDW,UND (2001)

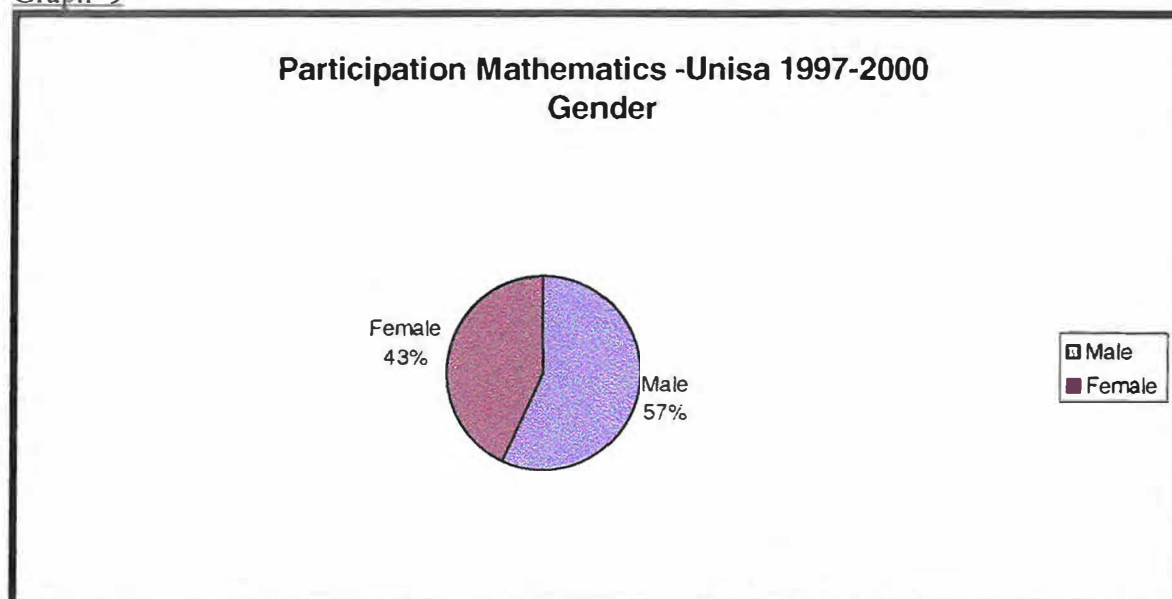
UDW and UND Performance		
Year	Male	Female
1997	60	30
1998	58	28
1999	34	20
2000	32	26

Graph 8



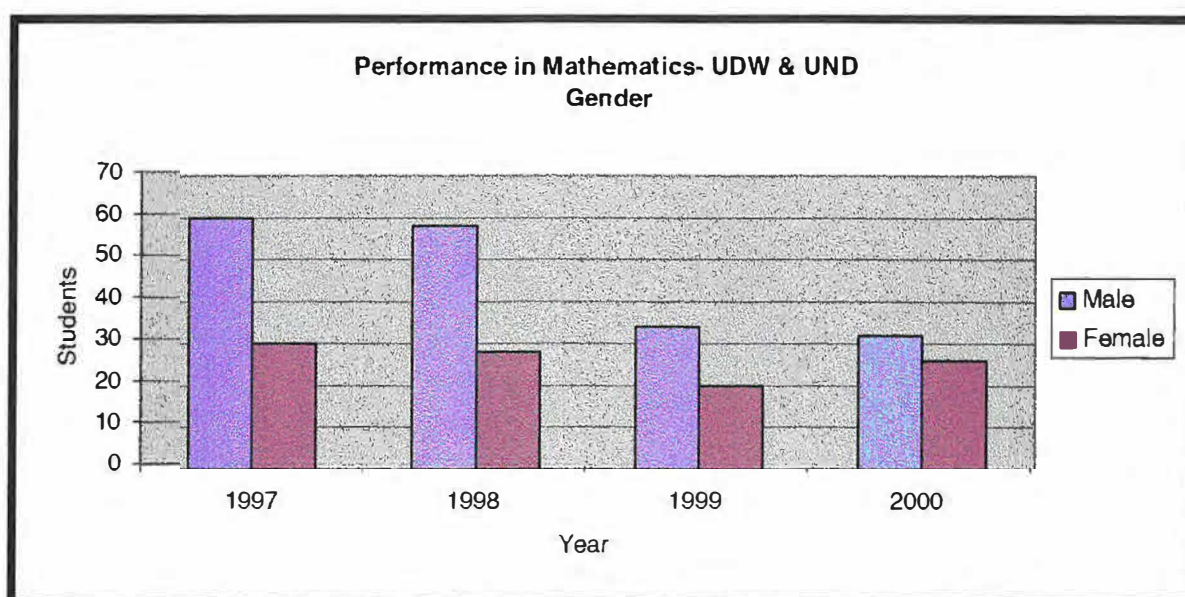
Source: UDW (2001), UND (2001).

Graph 9



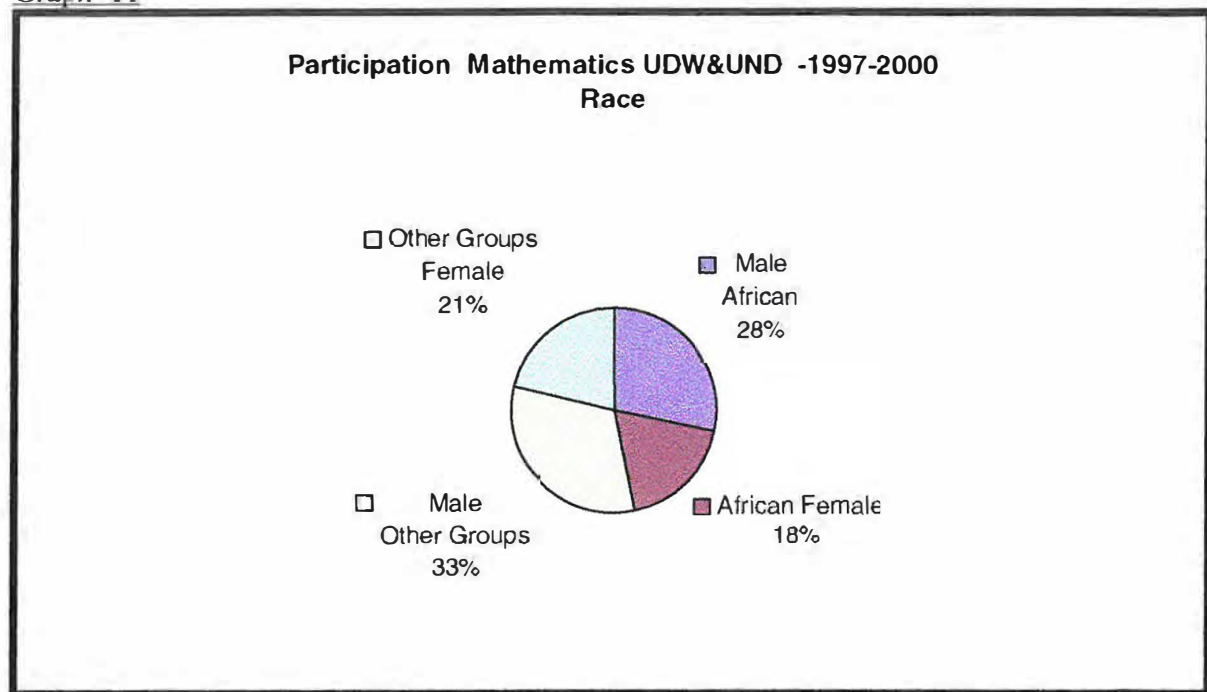
Source: Unisa (2001). Table – Appendix 6

Graph 10



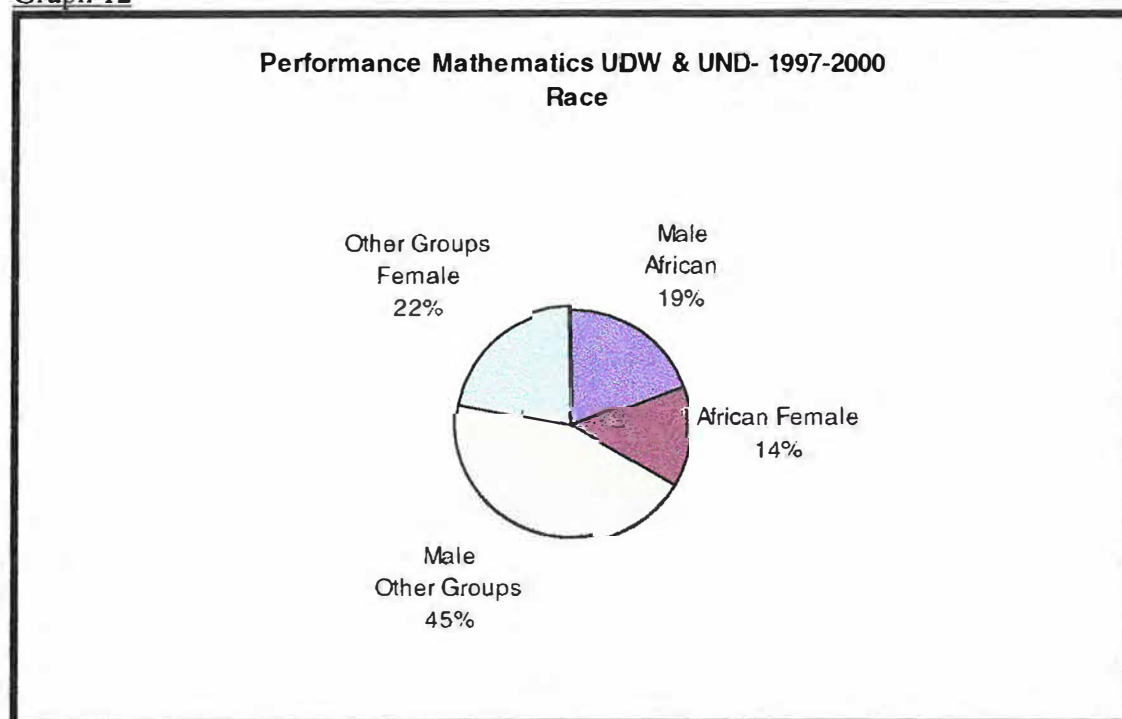
Source: UDW (2001), UND (2001). Table 5.

Graph 11



Source: UDW (2001), UND (2001). Table Appendix 6.

Graph 12



Source: UDW (2001), UND (2001). Table Appendix 6.

For all three universities, 'Mathematics' or 'Mathematics Related', degrees are those degrees for which a student registers and mathematics is a prerequisite course, if it is not already a choice. The graphics show segregation in terms of race and gender. Participation referring to the number of students that are registered for mathematics in that year. To reiterate, the intention of the data was not to evoke an institutional comparison of how each university is functioning or their effective input and throughput, but rather to examine the gender and race trends that exist around most mathematics and mathematics related degrees. In particular, the intention was to focus on the participation in mathematics by Kwa-Zulu Natal females compared to males, to examine their performance and choices in mathematics, which generates the continuum to their future employment prospects and thus the socio-economic status of women.

The evident lack of participation and performance in mathematics by African females is of grave concern, primarily because this grouping constitutes the largest single population demographic in Kwa- Zulu Natal (Statistics South Africa, 1999). It is certainly the largest demographic component, comprising learners at Ridgepark College. Graphs 11 and 12 draw special attention to the participation and performance of this group in mathematics. Graph 11 shows that they comprise only 18% of the total mathematics student population and then at graduation only 14% of the graduates in mathematics will be African females.

4.2.4.1 Participation in University Mathematics- Discussion

In examining the participation statistics of females at the three main universities, that serve Kwa-Zulu Natal, I found that consistently, smaller numbers of females compared to males choose mathematics degrees, see graphs 8 and 9. The graphs are drawn, showing male followed by female participation alongside each other for an instant gender comparison. Graph 8 shows a decline overall, in the number of women that choose mathematics, from 1997 to 2000. 2000 showed an increase in the participation of African women at UDW, for the first time in four years, see Appendix 6, while the other population groups showed the consistent decline in female participation. Unisa, a university that feeds nationally showed that the rates of participation of males to females, appears to favour males overall, graph 9. Could we

infer then, that the trend identified by this study for Kwa- Zulu Natal, be extrapolated nationally?

Participation in mathematics, examined along race, Graph 11, indicates that African females, at 18% of the total student population, are choosing mathematics the least. Note that the African female group has been compared to the combination of the other race groups (viz. Indian, Coloured and White). Coloured and White students, in particular, have very low levels of participation in mathematics for both genders, and were not showing up significantly on graphs. This necessitated the examination of African students as a group compared to a summation of the other groups. In examining Graph 8, we further find that in general, the number of students choosing mathematics is declining. The consistent decline in the bars from 1997 to 2000 is evidence.

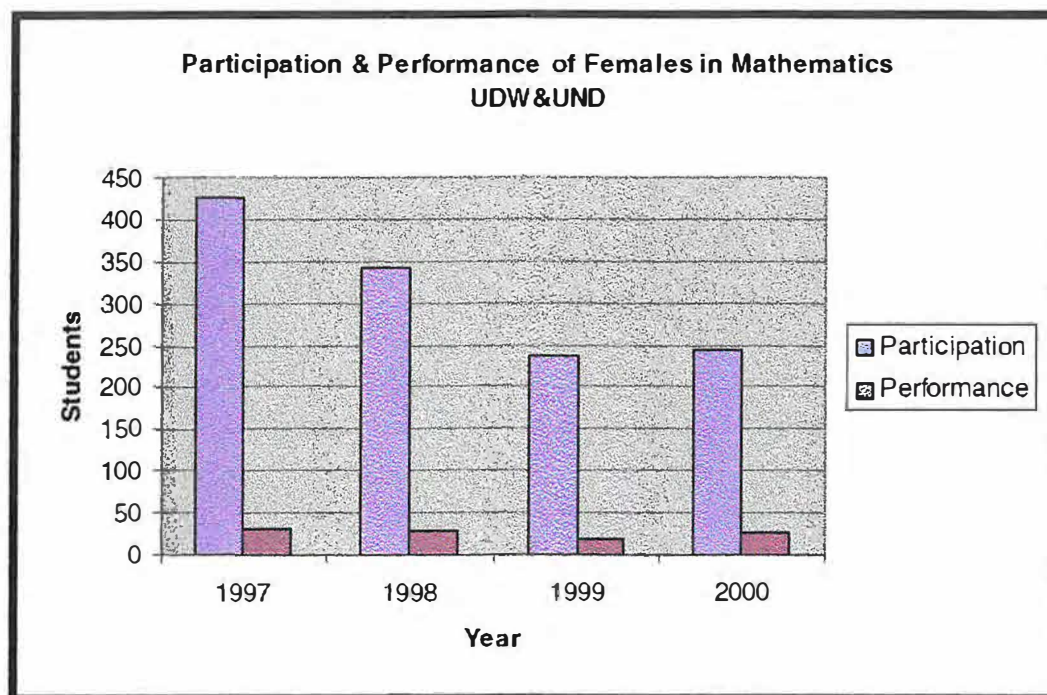
4.2.4.2 Performance in University Mathematics- Discussion

The term performance in this study refers to the number of students that graduate having studied mathematics at university. As with participation, the summative performance of males appears better than females, in general. See graph 10. Males consistently out –perform females in graduate numbers, their performance bars are always higher. While the number of graduates in mathematics, has fallen over the last four years, the year 2000, graph10, showed an increase in female graduates compared to previous years. Note that females have not passed males in the graduate count; they have improved on the female count from the previous year, 1999. We have compared the numbers of males with females in terms of participation and performance and found that **generally males out-participate and out- perform females in mathematics.**

Females Only! Performance against Participation in Mathematics at University

While the gender comparison is important, it is equally important to examine how females, themselves, are performing. Many register for mathematics or related degrees, how many graduate? The graph that follows illustrates the ‘attrition’ rate of females. The complete statistics of participation and performance at the universities of Durban-Westville and Natal – Durban have allowed data to be combined in the graph below.

Graph 13



Source: UDW(2001), UND(2001).Appendix 6.

This graph reveals the stark reality of mathematical competence: many females register, perhaps opportunistically, for mathematics, but few, actually graduate with mathematics. It should be noted also that mathematics may be taken as a service subject, in the first year, for other professions and qualifications. This can be attributed to the further depletion of the number of females that prolong their involvement with mathematics. The participation columns of the graph (in blue) overwhelm the picture and dwarf the performance columns alongside them. There is vast disparity between the input (number of females that register for mathematics degrees) and through-put (the number of females that graduate in mathematics) rates. The performance bars are exceptionally lower than the participation bars alongside. Even though there is an increase in 2000, it does not appear significant comparatively. Overall, we can see that female involvement with mathematics is on the decline.

This chapter has given voice to the statistics on female participation and performance in mathematics. In the next, we hear the voices of mathematics learners at school... what are they saying about their participation and performance in mathematics and when are they planning on cutting ties with mathematics.

Chapter 5 - Analysis

Give everyone a voice!

5. Reading the Entire Sample

Against the macro context of the dismal performance of females, in the previous chapter, it becomes critically important to understand what happens to females who choose to participate in mathematics. In this chapter I analyse the autobiographies and questionnaires of 20 learners in my Grade 12, Mathematics, Higher Grade, class. I will use my experiences and observation as their teacher as data. The themes of 'participation', 'performance' and 'choice' in mathematics are in the main the focus of this study and used to categorise the data that I had received from my girls. They provided rich, intense and exciting feedback, as will be seen in the selection of narratives, in the next chapter. From my reading of the entire sample, I distilled sub-themes, along which the information seemed to adhere and placed these in the categories of 'participation', 'performance' and 'choice'. The table below succinctly, describes the sub- themes that arose.

5.1 Participation	5.2 Performance	5.3 Choice
5.1.1 Classroom/School Organisation	5.2.1 Explaining success	5.3.1 Choosing Mathematics
5.1.2 Language of Instruction	5.2.2 Meaning and Content	5.3.2 Choosing Careers
	5.2.3 Role Models	

5.1 Participation in Mathematics

These 20 girls are successful in mathematics, by virtue of being on the higher-grade and among the top performers in the school. The class, as a group, produces the highest average on mathematics tests, in the standard. Recall, that I wanted to examine the participation, performance and choice that successful girls make in mathematics. What are factors that affect their mathematical performance? How do these successful girls exercise their mathematical choices? It was this train of thought, that informed my splitting of this group, of twenty learners, into three sub-groups, which I called, High, Middle, Low. This categorisation was based on their Year Mark that was submitted as their Continuous Assessment, for the year 2001.

The 'Year Mark' is calculated using all class assessments, standardised tests and examinations that the girls may write through the year. The categories had the following parameters: High -were the learners that achieved 70% and above on the Year Mark; Middle – learners 50% to 69%; Low – below 50%. They held 8, 7 and 5 girls respectively. I tabulated the data from the autobiographies and questionnaires into the three mentioned categories. This enabled me to understand, how girls, on the higher grade in mathematics, yet in different performance groupings, behaved and exercised choice and allowed me to examine in the chorus of their voices distinct sub-streams. The girls in the Low Group and a few of the Middle preferred that their names not be disclosed and I have thus withheld all names to respect their privacy. Each girl has been assigned a number to preserve anonymity (as many requested) and to facilitate a method for referring to their documented words. The numbers that appear in parenthesis, on the tables, indicate the number of females, in the sample of autobiographies and questionnaires, who responded positively to that idea or practice.

5.1.1 Participation linked to Classroom and School Organisation

High (8) (70% - 100%)	Middle (7) (50%-69%)	Low (5) (0%-50%)
<u>Learning Mathematics at a single-sex school</u>		
63% observed that the school's environment had made a difference to their learning (5/8)	57% indicated that the single sex school had contributed positively to their learning in mathematics (4/7)	100% of the girls responded that being at an all girls school did make a difference to learning, although it was 'boring' without boys (5/5)
63% of this group felt there was no obvious /apparent barriers to learning Math, for females (5/8).	86% thought that it was good not to have boys distracting them (6/7)	100% related the difficulties that they experience in mathematics to their own limitations and not to being female (5/5)
25% noted that they were out-performing their male friends (2/8)	43% thought that girls worked differently from boys. That girls understood that they had to sacrifice to succeed (3/7)	
	100% of this group preferred the order and structure that the school's mathematics programme offered. (7/7)	

High (8) (70% - 100%)	Middle (7) (50%-69%)	Low (5) (0%-50%)
<p><u>Self - worth as a function of Success in Mathematics</u></p> <p>100% of this group said that they valued being streamed in the 'A' group at school and that they worked hard to maintain this standard (8/8)</p> <p>100% felt that being good in mathematics validated their self - worth (8/8)</p> <p>63% equated mathematics with hard work (5/8)</p> <p>13% or only one learner attributed being good in mathematics with natural ability</p>	<p>72% felt that maintaining a higher grade pass when most girls were failing mathematics was an achievement (5/7)</p> <p>all girls felt that they were 'just average' in mathematics (7/7)</p> <p>100% felt that mathematics was synonymous with hard work.</p>	<p>100% related the difficulties that they experience in mathematics to their own limitations and not to being female (5/5)</p> <p>100% felt that the mathematics covered in class was easy to understand. The difficulty arose translating what was learned during a test / assessment situation (5/5)</p> <p>all girls felt that they worked really hard and could not understand why they were doing so badly. They felt that formal tests neglected to test what they know.</p> <p>all girls felt that despite performing poorly in mathematics they would always choose to do mathematics.</p>

High (8) (70% - 100%)	Middle (7) (50%-69%)	Low (5) (0%-50%)
<p><u>The teacher</u></p> <p>63% linked their performance to the type of teacher. A teacher that is passionate and knowledgeable was valued (5/8)</p> <p>89% felt having a female teacher, a motivator to succeed at mathematics (7/8)</p> <p>Teaching approach used on this group: ordered, fast-paced, competitive, and to the group as of homogenous ability (myself)</p>	<p>25% observed that the 'good' classes get the 'good' teachers. (2)</p> <p>71% felt that having a female teacher showed that it was possible to overcome the problems and difficulties in mathematics (5/7).</p>	<p>A good teacher was crucial for learners to understand the mathematics (5/5)</p> <p>60% felt that the gender of the teacher did not affect the way that they learned mathematics</p>

Discussion

This was a highly motivated group of girls, who worked enthusiastically in lessons. They actively sought understanding, and independently would undertake additional work and expect feedback. Of the total complement, no one expressed any regrets at being at an all-girls school. In fact, they all felt that it had contributed positively to their level of work and work ethic. One learner Fathima (Girl 1- questionnaire), moved with me from my previous co-ed school to Ridgemark College, indicated that she never knew that she could '*work so hard or do so well*', as she had done at Ridgemark. The absence of boys was treated with good natured humour, no one felt that they seriously lacked in social skills as a result of the boys absence, '*we have boys in my maths tuition class, they take a long time to settle down*' (Girl 3- questionnaire), and another mentioned that '*girls appear more mature in attitude and serious about their work than boys*' (Girl 8- questionnaire) or simply, '*we miss them, like we miss the measles!*' (Girl 13 – interview). Two learners, in the middle group, thought that it was helpful, not to be '*distracted*' (Girl 2 and Girl 12- questionnaires) by boys.

While some girls felt relieved that they did not have to deal with the dimension that boys bring to learning in a mathematics classroom, to others it appeared that the absence of boys did not make a difference, '*I studied with them in Primary School, it was nothing special*' (Girl 9- interview). The High Group were very confident of their ability and this seemed to be bolstered by the fact that they were out-performing many of their male friends, at other schools, '*I think, ha! You were beaten by a girl*' (Girl 5 – interview). Studies have found higher self-esteem for girls in single –sex schools (Boaler, 1997). 12 of the girls of the entire group attended additional lessons in mathematics, at least once a week. These classes were co-ed and they could adequately contrast their efforts in both settings. They felt they could produce better results at an all-girls school encouraged a more disciplined and strong work ethic, '*in lessons we settle down to work, there's no time for pranks*' (Girl 12 – questionnaire). Brutsaert and Bracke (1994), however, found little effect of the type of school, on grade 6 learners in Belgian elementary schools.

Ridgepark has a rigid and strictly enforced policy regarding school dress. Fancy hairstyles and interpretations of the school uniform are not allowed. By the time that the girls have reached grade 11, they have bought into the convention, with a sense of pride. I have watched many of these senior girls, assist new- comers to the school as well as those that choose to rebel rather than conform. The dynamics of physical appearance are therefore controlled very well and aspects of physical appearance among growing girls, that could prove distracting, particularly, in a mathematics class, are left outside. The girls came to mathematics, in the last three years with me, prepared to work.

Granleese and Joseph (1993) found that girls at single –sex schools were less critical of their behavioural conduct than girls in mixed schools. This lack of criticism, they called the single best predictor of self-worth in an all girls' school. In a mixed sex school, they found that physical appearance was the single best predictor of global self-worth. Here at Ridgepark the girls felt that doing well in mathematics was an achievement, one of which, they would feel very proud. All girls, in all categories regarded success in mathematics as very important. Not doing well, on an assessment affected them deeply, '*there is nothing that I can think of, that depresses me more than failing a maths test*' (Girl 15- interview) or '*I got such a shock when I got a*

C'(Girl 9 – autobiography). In the study mentioned above, it was found that girls and boys were unaffected by the organization of the school, but, that boys were affected negatively by a preponderance of female staff, which seemed to lower their overall sense of well-being. 80% of the autobiographies, reflected a large component of learners that thought that having female teachers meant that mathematics was accessible to them and that it was possible to succeed at it, as their teachers had, '*my female teachers have helped me see that success in mathematics is possible*' (Girl 5 – interview). The High and Middle groups seemed to be the most vociferous on this point. The remaining girls thought that the gender of the teacher was of little consequence.

Many studies found that girls in single – sex schools may have stronger preference for mathematics and science than their counterparts in co-ed settings. All girls, even those in the Low group indicated that they would always choose mathematics if given a choice, despite having moments that were very challenging. Studies like Mallam (1993) found that girls, in all-girls Nigerian schools, favoured mathematics more than girls in co-ed schools, particularly when female teachers taught mathematics and are confirmed by the feelings of the majority of the girls in this group. This single –sex school seems to foster a less stereotypical view of subjects and many girls perceive the school to be more orderly. These girls in particular, found the single-sex classroom more conducive to learning, that '*every thing had its place*' (Girl 12 – autobiography). All girls showed a preference for learning in a structured environment. There however, appears to be a lull in the research that shows that girls in single-sex schools achieve significantly better results than others or that single sex schools contribute to a significant gain in mathematics achievement.

Generally, at this school, the classes that are considered higher ability are assigned teachers that have proven good results at matriculation level. This motivated the comment from a girl in the Low group that she had observed that '*the good classes get the good teachers*' (Girl 18- questionnaire). All mathematics classes at the school are 'setted' or 'streamed' according to the girl's final assessment for the previous year. The girls with the higher scores could generally be found in the same class. Bell (1993) and Boaler (1997) showed that in common national examinations, it was seen to be the system that worked best. Such therefore is the system under which

these girls are taught. This school justifies the setting based on such research that has shown middle class parents prefer the setted system and that middle class learners, that are confident, thriving on competition and pressure and who are motivated will do well in setted systems.

Factors that characterise top set mathematics groups include rapid paced lessons, competition and pressure to succeed (Boaler, 1997). These girls in this setted system, felt that they were constantly competing with their peers and they saw this as contributory to raising achievement, particularly amongst the top achievers in the class that felt pressure to keep achieving. *'many girls come to me for help.... we constantly sit in the prefect room and compare our test marks... I have to keep working, I don't want embarrass myself!'* (Girl 20 – questionnaire), were Promise's words. In addition, these girls felt a sense of pride in being perceived as being the top- performing class, *'I know that we are regarded differently by the learners in the other classes, they will not touch the tests we write. They feel they are too difficult'* (Girl 19- questionnaire).

As far as my teaching went, I was able to teach faster paced lessons and expected more from the High Group. I expect that they will make sense of lessons. Having higher expectations of your learners and competition amongst higher achieving groups, correlates positively with achievement (Boaler, 1997). However, on the other side, many learners who are unable become disaffected and attainment starts to decline, *'I just don't seem to be able to get a good mark'* (Girl's 11,15,18,19- questionnaire) was frequent refrain particularly in the Low Group. I see this in my practice manifest as a large divide between girls that do well and those that perform poorly.

The Black girls that participated in this aspect of the study totalled 18/20. I could make no distinction between the ways that these girls learned mathematics on the basis of the race group they belonged to. The girls that performed well, each have developed complex, intriguing and individual ways of coming to know the mathematics that they had to learn. From the table, we're able to see that the girls in the Low category, in particular felt a sense of anxiety around mathematics, as if their efforts were not being affirmed, *'I try very hard, but I still perform terribly'* (Girl 15 –

interview). Oakes (1990) showed that ability grouping or streaming dooms the majority of 'non-white' learners to low achievement and lack of educational opportunities that drives them further into the disadvantaged status. We can easily criticise setted systems as being elitist and missing the majority of learners in mathematics. To this end, they can be labelled as discriminatory. 12/20 learners were scoring average to below, on their assessments. Such systems appear to fix and compartmentalising human potential. Setting of learners into homogenous groups has been shown to induce extreme anxiety in girls and can be blamed for misunderstandings and a hate of mathematics amongst girls, confirmed by girls in the Low category and Walkerdine (1989). Correlating to the strong responses of 'suffering and sacrifice' amongst the Low Grouping. From this I had to ask what made my 'non-white' (as Oakes (1990) would call them) girls in the Higher Group continue to succeed mathematics. I attributed this success in the end to a "way of working" that they had developed, almost an in-built drive, and a conscious decision, to succeed in mathematics. They would easily risk sounding 'foolish' by asking a question that would seem to have an obvious answer if it would assist their understanding. The girls that did well were more prepared to take risks and make mistakes than the girls who were performing poorly and who were generally more reserved.

This study makes the point then, that to compensate for the lack of confidence among the 'weaker' girls the mathematics curriculum and mathematics classroom have to be 'unstreamed' to achieve equity of access to mathematics among girls. We have to assess how girls learn in the context of race, class and culture. Our traditional means of teaching are clearly deficient in that they reflect a single method of instruction, a single means of learning, memorisation of facts in a particular sequence, within rigid time frames. In discussing the expectations that teachers have of the High Group there is the concomitant effect of teachers underestimating the potential of the learners in the Low Group. And when this group is diverse in terms of race, culture and class then this impacts on not only this relatively small group of learners but has far reaching implications for society in the future. 60% of the girls in this study, the Middle and Low groups, happen to all be Black, and the potential for employment equity to be addressed, in fields that are mathematics and science related, when these girls are ready to enter the employment sphere, is dismal. Setting seems to have

enhanced, the experience for learners in the High set, who generally appear to thrive on competition and maintaining their position in the aggregate hierarchy, and diminished that of those in the low set, whose expectations appear to want to just get by. This polarisation is very apparent, if we examine the grade 12's of which this sample is a component, where we have a class that performs extremely well (based on test and examination averages), and, the other two classes that perform very poorly.

In addition, the girls in the middle and low grouping frequently refer to stress and anxiety that they experience in mathematics. They appear to understand the work while it is being taught but in assessments (tests and examinations) they find difficulty in exhibiting what they have learned, '*I understand the work as it's done in class, I work really for tests, but in the test I just cant seem to cope...everything seems so strange*' (Girl 11 – autobiography). Groups that are homogeneous in ability exert a more reflective pressure on learners who feel that they are constantly being judged alongside their peers (Boaler, 1997), '*I study hard so that I can maintain my position and success. It would be difficult to be among all the prefects and admit that I had failed a test*' (High Girl 9 – interview). Successive failure amongst these girls leads them to disliking the subject, '*Nothing I do seems good enough*' (Girl 4 – autobiography) and is linked strongly to the way that they eventually exercise career choice, '*I want the torture to end!*' (Girl 4 – interview)- when asked why she was so vehement about not choosing a career in mathematics.

I, as their teacher, have also to be critical of the approach under which these girls learn mathematics: it is very controlled. The theory is transmitted through talk and text. Literature terms this 'curricular fundamentalism' (Ernest, 1994), where learners are not given the opportunity to use, think or discuss the mathematics that they learn. In the mathematics department, many teachers consider teaching and learning to be synonymous and therefore much of school learning is done by rote. They see no difference between clear transmission and understanding. They are supposed to follow each other automatically. This was confirmed by Sigurdson and Olsen (1992). Setting, high-pressure learning, the transmission of closed pieces of knowledge this study shows forms the basis of weaker students disaffection, misunderstanding and

underachievement, ' *I work really hard in tests, yet it doesn't seem to help*' (Girl 16 – questionnaire). We as teachers, and the learners in the Low group frequently attribute failure to girl's inability to work hard enough. For example, 16/20 report cards, for girls in this group, for the June Examination indicated comment equivalent to '*needs to work harder in mathematics*'.

Seldom do we, as teachers look to the very conservative and traditional issues on setting, speed, competition and pressure to examine as reasons for performance, underperformance or dislike of mathematics.

5.1.2 Participation related to the Language of Instruction (English)

This was a higher-grade mathematics and a higher grade English First Language class. All lessons are conducted in English, the language of instruction of the school.

High (8)	Middle (7)	Low (5)
<p>All learners in this group had English as their first language (8)</p> <p>All indicated that they were seldom confused about the way that English was used in teaching and in learning materials (8)</p> <p>Difficulties in mathematics related to difficulties with mathematical concepts and not to the medium of instruction (5)</p> <p>Were not intimidated by the language of mathematics and were excited about finding a solution (5)</p>	<p>This was a mixed grouping in terms of the first language (isiZulu (3/5) and English (4/5)).</p> <p>The responses from isiZulu speakers centred around:</p> <ul style="list-style-type: none"> ▪ finding it easier to express thoughts in isiZulu (2) ▪ some felt inadequate their use of English to explain a mathematics problem (2) ▪ some felt intimidated by the English in texts and tests papers (3) ▪ all learners felt comfortable to converse in English (3) ▪ 2 indicated that they wanted to feel excited about the challenge and not apprehensive when they read a problem (2) ▪ there were strong feelings of wanting 	<p>2/5 of this grouping was English -Second - Language learners.</p> <p>Responses relating to learners that feel insecure expressing themselves in English</p> <ul style="list-style-type: none"> ▪ 3 girls found it easier to express their thoughts in isiZulu (3) ▪ all did not feel sure of themselves when communicating in English (3) ▪ they felt afraid to question and to ask for clarity in lessons (3) ▪ felt that subtleties in logic were lost due to them thinking in Zulu after hearing the mathematics in English (3) ▪ all preferred mathematics to English, as they did not have to write

	<p>to gain the approval of the teacher (3/5)</p> <ul style="list-style-type: none"> ▪ learners saw mathematics as a foreign, external component in their lives that they had to learn and make sense of. They could not ease into mathematics (3) ▪ all learners felt that they took longer to understand the concepts than the other girls (3) ▪ all felt that they would not try explaining mathematics to others. They preferred to be silent when explanations were sought in class. This despite having the correct answer (3) ▪ Ridgepark was the first time these girls had to speak English outside an English Classroom (2) <p>The first-language-English speakers difficulties centred around mathematics concepts and not language. Their concerns were:</p> <ul style="list-style-type: none"> ▪ They had to pass mathematics (4) ▪ That they had to keep up with the girls that were considered good (4) ▪ They were desperate not to fail (4) 	<p>long essays (3)</p> <ul style="list-style-type: none"> ▪ display insecurity in the way that the mathematics was understood
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Discussion

I found that the High category expressed excitement about tackling a new problem. My, IsiZulu first language learners, approached a problem apprehensively, *'waiting to get to a point where I will not understand anymore'* (Girl 15 – autobiography), especially the Low group. They indicated that they also didn't like reading long problems, which could be related to confidence in English proficiency. All my African learners, in the Low group felt more confident expressing themselves in isiZulu. One learner (Girl 13) recalled in her autobiography having being held back a year at primary school to better her English. To qualify further, I found the High and Middle girls were more confident when it came to asking questions in class or in the engagement of discussion. I noticed that my African learners in the Low group, in particular, were silent, shy or became embarrassed if asked questions during a lesson. They seldom initiated questions. Their insecurity was revealed by their responses in the questionnaire where they indicated statements such as, *'I sometimes just can't understand what we are doing. I can't bring myself to ask my teacher to explain'* (Girl 10) or even more dangerous was the comment that, *'I keep waiting to get to the point where I will stop understanding what we are doing...I end up sitting in my usual muddle'* (Girl 15 – autobiography). It was almost as if she was willing herself to a point where she would cease to understand. She shows an acceptance of this as though it is usual, expected.

The Futurefact 2000 report, from the University of Cape Town (2000), author not provided, found that 16% of South Africans and 20% of Black South Africans do not understand English at all. With a further 16% and 20% respectively claiming that they have poor or not a very good understanding of English. This they say translates to 58% of the adult population having a relatively good understanding of English. Ridgepark College enforces its code of conduct that states that, it is an 'English medium school' and 'only English' can be spoken during instructional time.

Extract from the Code of Conduct at Ridgepark College reads as:

2. BEHAVIOUR WITHIN THE SCHOOL GROUNDS

2.1 Whilst in a CLASSROOM or in the GROUNDS a learner

2.1.6 will speak the language of instruction (generally English) whilst in the classroom and when addressing Staff, prefects and learners. Exceptions to this rule will be Zulu and Afrikaans lessons.

The girls refer to this aspect of the code of conduct with surprise, '*Ridgepark is the first school where I am expected to speak English only*' (Girl 13 – autobiography). To me this policy is draconian in light of developing and respecting multilingualism and it contradicts our understanding of how mathematics should be learned in the multilingual class.

Despite the policy, I've heard isiZulu being spoken in intimate groups in the Mathematics classroom, in the context of one learner explaining to another something that she could not understand. All interactions that demand the attention of the entire class, with the teacher or other learners, are however, conducted in English. Fluency in English has been associated with performing well in mathematics, especially among the girls in the Low group, they consider the way that they try to understand the mathematics to be somewhat defective as they will not understand the full truth, due to their perceived lack of fluency in English. Certainly, this study confirms that poor English skills contribute to anxiety and demotivation in the Mathematics classroom if we examine the composite of responses from the learners in the Low group. Mullis (1997) found that in South African schools, only 26% of pupils spoke the language of the test (English or Afrikaans) as their first language. A criticism that was levelled fairly at the TIMMS Study. The English -Second -Language (ESL) learners in the middle group (2) were comfortably tri-lingual (English, isiZulu, Afrikaans) and indicated that they preferred isiZulu but were not unduly stressed by the use of English. The Low Group (3) would have preferred isiZulu, categorically. The Unilever Institute of Marketing's Research for 2001, conducted by the University of Cape Town, showed that 4 out of 5 students want to receive information in their own language and over 50% preferred an African language, re-emphasising the findings in this study.

The girls in the High Group seemed more involved in a variety of school activities when compared to the girls in the Low Group. Also they appeared to read more. It was usual, to find any one of these girls reading a novel once they had completed their mathematics for that day. Cresswell's (1993) study that found that reading achievement influences mathematics problem solving, regardless of sex or ethnicity. All girls in the High Group were English –first language learners supporting Dawe (1983), who found that first language competence (i.e. Zulu competence for first-language- Zulu speakers) is important for reasoning mathematically in English. It would therefore appear that apart from developing English competence, which I'm sure, is the spirit behind the Code of Conduct; first language competence needs also to be developed. The school is neglectful of this as it enforces the hegemony of English appropriation. In policy, the Foundation Phase has been developed to improve young children's home language skills. In addition, Kader Asmal (2001a) said that the FET (Further Education and Training) program was developed to improve older pupil's English skills, especially those needed for passing mathematics, science and technology.

As a teacher, I had the perception that mathematics transcends linguistic specifics. That language, particularly in the mathematics classroom is used as a resource rather than a problem (Adler, 2001). Parallel run the practical considerations, that we have the majority of mathematics learners being taught by a teacher who does not share their linguistic base. Nuances are definitely lost on the learners and understanding compromised, especially in the implicit. Hence, the reservations that ESL learners express when being drawn into the classroom discourse. Ridgepark College along with the larger teaching fraternity needs to improve the bilingual clarity of White and Indian teachers (with respect to English and IsiZulu), and to assist them in the engagement of learners that are marginalised by language. Further to this, we need to examine the conceptual content of teacher's explanations and their ability to stimulate and extend learner thinking and talk. Particularly, the Low group had excluded their voices from the classroom discourse. They do not mention if there was any effort on the part of the teacher to draw them into a discussion because there was none. Their language proficiency suffered and their helplessness in mathematics was assisted by myself who thought it best that they not cause them embarrassment if they were unable to answer a question or answered it incorrectly. Teachers need not be required

to be fluent speakers of the language of the majority of learners, but they need to understand the language that the majority of learners are secure in so that at any time they will be able to understand and facilitate the learning of mathematics should the girls opt for the more comfortable code.

The table revealed a strong sense of anxiety that is felt especially by learners who were low achievers, *'to me mathematics equals pain and suffering'* (Girl 14-autobiography). Clearly, attitude and mindset are contributors to achievement. Further, these learners do not seem to show a sense of ownership of the mathematics that they learn, *'why do I have to learn this stuff, I will never use it'* (Girl 19-autobiography). It is a separate, body of information, itself, a different language, on which they can exert no influence and from which they are becoming increasingly alienated, than learners that are succeeding. It appears way beyond their locus of control. The relegation of mother tongue to very restricted parameters, has not been shown to improve English competence among isiZulu learners, nor has it shown to improve mathematics competence. Those Mathematics teachers who choose to suppress the use of mother-tongue (other than English) are alienating learners that would otherwise be engaged in sense making. Politically, this can be perceived as oppression.

With 3/5 of the Low achievers being African and this trend persisting at University level, where tragically fewer African learners graduate, see Tables in Chapter 4, one can speculate that mathematics cannot be perceived as an African domain. To qualify this, all of the 20 females in this sample saw mathematicians as white males or as objects (a large Oak tree with many branches and leaves-imposing, inaccessible, difficult to penetrate). No one knew of any black mathematician, though the group was sure that they did exist. An 'African /Black Female' mathematician however, as a profile had not even been conceived as a thought. This lack of affirmation and identity with other females in the field contributes to learners being emasculated, creating further barriers to learning.

For the lower group specifically, while attention had to be paid to the content that had to be taught and learned, motivational techniques, less rigid time constraints on sections that had to be covered, the expectation of higher standards of participation

and performance, adequate time on task, regular homework and judicious monitoring of it, have to be combined to improve performance. The syllabus and curriculum have to move away from being prescriptive to being more flexible to cater for the varying abilities, interests and languages of learners. To illustrate, mathematics of finance, can be offered to learners who will be able to enter the banking world at lower levels or to the entrepreneurs. The lower achievers need to be situated in mathematics that is tailored for their abilities and interests and which at the same time, can offer them access to more advanced mathematics after school. The present curriculum is very one-dimensional: you enter, follow the stipulated path, and exit after the common Matriculation examination. Validation, as a competent member of the society should you pass or... relegation, to the bottom of the economic societal heap should you not!

5.2.1 Performance related to how Females Explain Success

High (8)	Middle (7)	Low (5)
<p>38% Learners considered themselves successful in mathematics (3)</p> <p>Only 1 girl thought that she had an amazing ability and that mathematics came naturally to her</p> <p>25% of this group indicated mathematics as their favourite subject</p> <p>100% of this group attributed their success to hard work, constant revision, regular homework and tests.</p> <p>100% did their diligently and used the homework to assess their understanding the section</p> <p>63% enjoyed the challenge of a problem (5)</p>	<p>Only one learner considered herself successful.</p> <p>Performance related only to hard work and not natural flair (7)</p> <p>Maintaining an average above 50%, especially when many other girls were failing was considered an achievement (7).</p>	<p>None of the learners felt they were a success in maths (5)</p> <p>Attributed their 'success' to just not being able. (3)</p> <p>Saw no point to what had to be learned and the homework assigned weighed them down (5)</p> <p>Were fearful before they started a problem:</p> <ul style="list-style-type: none"> ▪ give up too easily (5) ▪ Mathematics is too difficult (5) ▪ Doing mathematics takes too much effort (1).

<p>Why success in maths is important:</p> <p>Intrinsic motivations:</p> <ul style="list-style-type: none"> ▪ Need to prove that they can succeed at mathematics (8) ▪ Enjoying the exhilaration of solving problems correctly (8) ▪ The need to conquer the unsolved (4) ▪ As sense of not wanting to give up (3) ▪ The meeting and exceeding of personal goals set for self (1) <p>Extrinsic Motivations</p> <ul style="list-style-type: none"> ▪ A good pass in mathematics guarantees acceptance into tertiary field (7) ▪ To live up to the expectations of parents and teachers (2) 	<p>Feelings on being successful:</p> <ul style="list-style-type: none"> ▪ Not wanting to disappoint (7) ▪ The need to prove worth in mathematics (5) ▪ I want to be as successful as the other girls that do well (7) ▪ I am desperate not to fail (7) 	<p>Feelings:</p> <ul style="list-style-type: none"> ▪ Why do I have to learn all this? (3) ▪ Mathematics tests are not fair they test what I don't know (2) ▪ Need a good teacher that can motivate me (3) ▪ Just cant succeed at mathematics (3) ▪ Test situations are very stressful (5)
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Discussion

The Low column reads like a litany of despair. These girls feel that they are simply unable to do mathematics ' *I try really hard but I just can't succeed* ' (Girls 4, 11, 16-questionnaires). While the other two groups may have anxieties, they seem to handle them more constructively and positively. They don't appear as having resigned to giving up. This lends support to Ames (1984b) who examined the anxiety that girls experienced in mathematics and their tendency to link their failure to their own perceived lack of ability. The syllabus/curriculum completely neglects the motivation of learners and the building of self-confidence. We can see from the table, that the girls, who are experiencing difficulties, feel a strong sense of failure. I see the Low girls enter the classrooms anxiously and even more so during tests and examinations. Seldom is failure treated as the opportunity to learn: the child is labelled, their actions

ignored, and the curriculum and pedagogy escape scrutiny. Anyon (1981b) called this the 'tendency to blame the victim'- where the responsibility for change is laid at the feet of the girls.

The majority of girls in this sample, under-rate their ability in mathematics. Only 25% of them thought that they were successful or able, correlating with Murphy's (1996) study, which showed, that girls underestimate and boys overestimate their performance. These girls lower expectations of success, their unfamiliarity with related experiences, translates to them approaching learning situations with diffidence and fear, '*oh Lord, we have mathematics now*' (Girl 16 – autobiography). We can see this progression across the columns from High to Low. The girls in the Low group clearly feel alienated from the mathematics teaching and learning experience, '*wish I knew why I had to learn all this*' (Girl 17- autobiography) or '*I need my maths teacher to motivate me*' (Girl 18 – questionnaire). Like mathematics departments everywhere, we at Ridgepark need to distinguish the effects of alienation from differences in ability, in order to more correctly interpret and effect the achievement of our learners.

Females in this study attribute their success to hard work and discipline, not natural flair or ability (only 1/20 thought mathematics came to her naturally- Girl 9). Four found Mathematics easy to learn (Girl 5, 6, 9, 19) with two listing it as their favourite subject (Girl 5 and Girl 9). Damarin (1991) linked this proactive liking of mathematics to later opportunity. It must be added, that none of the girls, even the High achieving group found the impetus to develop interest and knowledge beyond the parameters of syllabus. They would master the solving of two equations simultaneously, but no one expressed curiosity about three equations in three unknowns or n-equations for that matter...

The prevailing format of mathematics lessons that these learners were accustomed to: teacher directed explanations and questioning, followed by learners applying the concept as class work, homework, paper and pencil tutorials, class tests, correction and remedial work, next section. The girls are arranged in co-operative groupings of 4 or 5 for class work sessions but all tests are administered individually. The Low group especially emphasised the anxiety that surrounds tests: '*during tests I feel my*

head buzz and my palms sweat' (Girl 6), they felt unable to perform, *'I know I tried a similar example but in a test its as though I don't know what to do'* (Girl 16), a simple error could render an entire effort redundant, *'and I lose all the marks'* (Girl 17), despite learning hard the Low group still performed poorly on tests. As a critique of my practice, I think that the girls found it difficult to reconcile the non-threatening environment of class work, with the competitive and tense environment of the test. Unfortunately, the assessment policy of this schools mathematics department, specifies the number of tests that each learner is expected to write and does not cater for co-operative assessments for matric learners. Head (1995) showed that girls prefer a co-operative learning environment and a safe non-competitive classroom climate. The above climate encourages co-operation during class work but the climate out of which the learners are rewarded for their efforts is an intensely competitive and individual one. Tests determine the Grade you're on, the mark reflected on your report card, your consequent parents reaction to your effort, even the classroom and teacher that you will get the next year. I have seen, because of this, many High achievers resist mentoring low achievers during class time as they found that it compromised their time on task and preparation for the next test. Girls that develop a male competitive edge to the learning of mathematics, in the present way that it is structured and taught in schools, will be more successful. They are expected to aggressively pursue understanding, when there are limited time constraints to develop learners within the present curriculum structuring of tests and examination requirements.

Females develop ways of responding to the world and understanding it, which has been informed by their homes, classrooms and what happens outside of these confines. This will impact on what and how they learn and how they see themselves in the classroom and later on in society. Mathematics, largely, is taught and structured as a collection of many different sections that are sequenced arbitrarily, *'no one tells me why I have to learn this or what I will use it for'* (Girl 17- questionnaire). The environment as already discussed, is pressurised and competitive, and the stakes for passing well is high. A new section is taught and learned in isolation, as having no relevance to previous work or any relation to sections that are to come. The relevance of what is taught is lost, we hear the desperation recorded for the Low Group above, when girls question what it is they have to learn. They struggle to put a purpose to it,

other than, that they have to know it for the impending examination. Gilligan's (1982) notion of separate and connected knowledge suggests that males and females had different ways of knowing and different ways of learning. Men preferring rigor, logic and abstraction characterising separate knowledge. Women prefer using creativity intuition, and experience-connected knowledge. A mathematics teachers approach to the curriculum will therefore have the greatest impact on how the learner views her mathematical growth and how the learner views the subject itself. I have found that the girls, judgements and even limitations, often closely reflect those of their teachers. A teacher that is unable to reflect value to the learners in what they are learning, that mathematics does not have to mean anxiety, that mathematics can mean enjoyment rather than long, endurance tasks or considerable work, that there is room for creativity and sharing, should take responsibility for the way that learners will view the subject as well as, the way that learners feel and behave in the subject.

In summary, being critical of the messages these learners are receiving would reveal: they do not understand why the Mathematics is sequenced as it is, 'I see no point to learning this, where does it fit in?' They do not understand why mathematics is compartmentalised/separated as it is, '*we learn a lot of unnecessary stuff*' (Girl 9 – interview). That they cannot use what they have learned, '*I will never use this stuff again*' (Girl 6 - questionnaire). There is a complete lack of affirmation of females in mathematics, '*I would admire any woman in maths, I know it couldn't have been easy*' (Girl 7- autobiography), '*maths tests what I don't know rather than what I know*' (Girl 10 – questionnaire); the lack of teacher recognition in ability, '*she would scream and leave, if we didn't know the answer. I started not to like maths*' (Girl 7 – interview); intuitive means of solving or understanding are not validated, '*I know the answer, I just don't know how to write it or to explain it properly*' (Girl 13 - interview); the mathematical worth of females is judged under very individual and pressurised circumstances of written tests, '*I am very anxious around tests and examinations*' (Girl 11 – interview). The system, consequently, leaves females with little confidence in themselves as mathematicians. Does mathematics then, offer to women the life that they would want to lead, in and after school?

5.2.2 Performance related to Meaning and Content

I have combined the Middle and Low Groups in this segment as I found the responses very similar and often repeated. Many learners did not provide the detail that I had hoped for. I worked with what I got.

High(8)	Middle and Low (12)
<p>The search for meaning:</p> <ul style="list-style-type: none"> ▪ Mathematics involves the learning of a lot of information that will never be used (5) ▪ A strong need to see the relevance of what is being learned (5) ▪ A need to see the contexts in which or from which, the mathematics that has to be learned, has evolved (2) ▪ How was this mathematics relevant to the lives of the mathematicians who developed it (2) ▪ Understanding assists learning (8) ▪ Why study geometry? (8) ▪ Mathematics equals hard work (8) ▪ Support needed from friends and teacher (6) ▪ Apprehension and stress around tests (8) <p>Proactive strategies employed to assist learning (8)</p>	<p>The Search for Meaning:</p> <ul style="list-style-type: none"> ▪ Understanding is most important (12) ▪ Sometimes follow routines without understanding them (9) ▪ Why geometry? (12) ▪ Questions prompt a particular solution (4) ▪ Mathematics is about remembering, most times without thinking (3) ▪ Support needed from teachers and friends (5) ▪ Transition from section to section is too quick (2) <p>Some strong feelings pertaining to assessment:</p> <ul style="list-style-type: none"> ▪ Tests present very pressurised and tense environments (12) ▪ Some questions require too much working for too few marks (3) ▪ It all depends if I can remember the technique, if I can't, I fell disheartened (2). ▪ There can only be one solution and one way of getting at it (7) <p>T030010</p>



Discussion

All learners seem to allude to the emphasis on procedural knowledge from which I can deduce the resulting anxiety when it comes to recall and application. Both groups seemed to stress the lack of connection of the mathematics that they learn, to everyday life and to sections that they had learned previously. Lave (1993) asserted that students do not use mathematics learned in one situation in another because the two situations different 'communities of practise'. All these girls showed this 'disconnection' in their understanding and learning, *'sometimes I don't understand why I'm doing what I'm doing'* (Girl 2 – questionnaire). They don't feel that what they have learned is usable and adaptable. All 20 girls, the entire group, could find no good reason to validate the studying of geometry. They would complain bitterly if a concept that was taught last year was tested this year, *'that is not what I was learning for'*, is the excuse, particularly for the High Group who aggressively pursue every mark in a test. Re- emphasising the disconnected, removed and separate ways in which they have learned to compartmentalise and treat the learning of anything mathematical.

They have learnt that mathematics is not about thinking, *'if I can't remember what to do then I'm lost'* (Girl 17- questionnaire). The learning of procedures/rules becomes the priority rather than the understanding of the procedures within the contexts of wider mathematics perspectives, *'there can only be one solution and you have to learn it'* (Girl 12 – questionnaire). These girls completely lack the confidence to adapt procedures to different situations. Hence, also the disillusionment, *'we learn a lot of stuff that we will never use'* (Girl 6 - questionnaire). They do not acknowledge that there are multiple paths (procedures) to multiple solutions (truths). The learning system has instilled passivity, where the learners appear not to explore, adapt or change. They have ceased thinking mathematically. Mathematics has been demeaned to being a memory retrieval process, *'it all depends if I can remember the technique'* (Girl 12 – questionnaire). Boaler (1997) suggests that when individuals develop meaning out of a solution, they do so through a process of perceiving, acting and creating meaning on the spot, rather than using their memory of representations that is stored in their heads. This sadly appears to be what these girls are resorting to.

I can categorise their mathematical behaviour in two ways: the first, these girls appear to approach a problem trying to recall rules that they had learned previously. They express anxiety when they're unable to find the specified way of working a problem out, '*I thought I had to think, in maths, I don't. I have to remember*' (Girl 4 – questionnaire). They believe that it is inappropriate for them to interpret or find the solution other than by specified means and processes that are taught in class. They exhibit tension and anxiety about tests and examinations, '*tests keep me constantly under pressure*' (Girl 9 – interview) and '*I work well in class, I just don't know what happens in tests and exams*' (Girl 11 – questionnaire). In tests and examinations they feel alone, and apprehensive compared to when they can work collaboratively in class. The second is where these girls look for cues. They answer questions based on what they believe is expected of them and not specifically what would be best mathematical practice. They derive the method/solution from the cues that are present in the question. To illustrate this, I examined a test that was written at the beginning of the year. The question involved finding the locus of all points around a specified centre, which became the equation of a circle. 5/7 girls of the Middle Group 2/8 from the High grouping left their answer $(x - 2)^2 + (y + 5)^2 = -13$. Procedurally, they were able to find the equation of a circle, by following the cues from the question and the algorithm that the visual format that the problem suggested (these types of problems usually follow the same process) but the negative radius squared, showed, that they did the process with little thought. These unfortunate occurrences, serve to contextualise mathematics teaching as equating understanding to the narrow procedural formats of tackling mathematics problems. These girls seldom bear the responsibility of finding best practice for themselves. They can see that mathematics cannot be applied on the outside, in non- classroom settings. It diminishes our responsibility to understanding and indeed to the richness of the subject.

I recall asking an open question to be included as part of their mathematical autobiographies, "*What about mathematics, would you change?*" Without exception, all 20 replied, that they would remove geometry from the syllabus. See table above. This shows a direct correspondence to the analysis of the matric examination where consistently the performance in the second paper (which has geometry as a significant

component), is poorer (Department of Education, 2000d). I will attempt to interrogate this on two fronts:

5.2.2.1 The Pedagogical Attack

5.2.2.2 The Female in Geometry

5.2.2.1 The Pedagogical Attack

What is it that we as educators are doing or not doing in Geometry? The 'doing' is easier to answer. All girls recall very similar experiences of Geometry: there is great emphasis on the textbook, the girls listen to the teacher who explains the theory/theorems that are required, then illustrates examples on which the theorem can be applied. Learners then work through the textbook exercises, in short, episodic, factual boxes. This seems to emphasise the algorithmic process: success is based on recall of processes and rules, on the picking-up of cues that are latent in the problem itself. The point is that *'if you can't remember then you can't do'*. The emphasis on the 'procedural' as discussed above, comes through strongly as teachers appear to be equating clear transmission, with understanding. This is the predominant pedagogy of geometry in these girls experience.

The Geometry class, more than any other, needs to build independence and self-motivation. It provides ample opportunity to show multiple paths to solutions, it can encourage individuality and creativity and an independence of thought in application that mathematics learners often lose. It needs to be an environment that stimulates learners; activities must encourage learners to think for themselves and to use mathematics. We can incorporate flexibility and creativity. Bell (1993) confirmed that intensity and degree of engagement were more important than time on task. We can while providing engagement, also stimulate curiosity and excitement. While the pedagogy of teachers can be criticised, it has to be done so in the context of the curriculum. We need a curriculum that supports girls learning. One that is activity-based, learner centred, in a co-operative environment, focussing on aspects of inquiry and discovery.

Many learners stressed that geometry appeared to be about learning rules and applying them and there was much anxiety about the inability to recall. They consequently missed the richness that can be found in geometrical discovery. All

categories wanted to understand the mathematics, '*I try to understand what I have to learn*'. It is a pity that the pedagogy doesn't allow them the chance to explore alternative solutions and ways of doing, of investigating different methods and when they are best used. There is a critical disconnection between curriculum, pedagogy and the mathematics of the real world. A derived axiom from this study would conclude, that females believe that the mathematics that they learned at school and the mathematics in the real world were completely and inherently different.

Every learner spoke of their parents support for them in mathematics and their parents almost insistence that they choose mathematics in Grade 10. Sex role development research (Secada, 1995) suggests that the home environment is crucial to encouraging success. It does not have to offer mathematical knowledge, but it has to show the girls the value of their participation and success in mathematics. Families also need to send out positive messages that affirm girls in mathematics. Having mothers and sisters that are constantly referring to difficulties that they experienced, is providing a female with an excuse for, and validating, not being successful in mathematics.

5.2.2.2 The Female in Geometry

Early socialisation has a dramatic impact on female's development of spatial skills. Geometry involves much strategy. Wilder and Powell (1989), comments on the different ways that parents respond to boys and girls and encourage them to interact with their environment and other people. We know that females seldom play games that involve strategic play or spatial orientation when younger. This was borne out in research done by Taylor (1986) among others. With earlier schooling, the expectations of teachers and peers would have been conveyed to the girls. In the classroom specifically, studies found that teachers give boys specific instructions to complete a problem but often show girls how to finish a task (Walkerdine, 1989). These girls have learned from their teachers and parents what is expected of them. In geometry, they appear to rely on the teacher eventually presenting the correct solution, '*... I don't understand ... I try for so long and when the teacher gives us the solution, its really easy*' (Girl 1- questionnaire). These patterns of behaviour are conveyed to learners verbally and non-verbally and the girls internalise and adopt these identities and expectations. Certainly through constant messages that geometry

is difficult or a teacher that supplies the 'perfect' solution, girls learn certain 'helplessness' in mathematics.

In an extensive, multi-state study, Flores (1990), found that in a geometry class, in which students read the book and did the problems first, and then had a classroom discussion on the topic, girls out-performed the boys on two of the five geometric measures and equalled the boys on the remaining. The lecturing, then reading the book, and then doing the problem favoured boys. The current predominant methodology of the geometry classes, at Ridgepark College, therefore favours boys. We have to structure the class so that homework and new material, such as reading and problem solving are previewed before the classroom lecture and discussion. This has been shown to improve girl's participation and performance. I plan to implement this approach in 2002.

This group of girls learns mathematics as a collective, with the identity of a group. Their individual questions remained unanswered. Perhaps teachers could ask questions of the individuals, so that the aggressive as well as the shy learners are attended to. Questions from learners could also be written down and answered the next day. The geometry class has to be an environment that encourages questions and all girls understand that their expectations are important. Hands – on active learning helps students develop confidence (Fennema, 1995). All the girls indicated that they enjoyed learning with the support of their friends and that they lacked confidence to speak about alternate solutions. The overuse of the lecture /discussion, seatwork, homework and tests has been associated with many women dropping out of mathematics (Walkerdine, 1989). Co-operative learning strategies that rotate tasks and reduce competition, where the atmosphere is regarded as warm and fair, favours girls (Eccles, 1985).

The ideal classroom should thus incorporate co-operative work and individual instruction. The importance attributed to examinations, however, puts teachers under pressure to ensure that the syllabus is completed. We then react by compromising the understanding of our girls, in geometry. Contemporary methodology is the most expeditious to achieve these objectives and unfortunately, it favours the learning

styles that, males prefer. We can relate this strongly to the participation and performance rates in school mathematics that were discussed earlier.

5.2.3 Performance Related to Role Models (in School , Home and Society)

I have chosen to present a summary of the girls responses and have neglected the categorisation of High, Middle, Low as many responses were common, due to a scarcity of female role models in mathematics.

- All learners knew of no other role models, in mathematics, except their teachers (20).
- Many felt that their female teachers illuminated a path that they could now see as possible, *"my teachers (being female), show that females can succeed in mathematics"*. (12)
- 3 /20 learners chose mathematics related fields for the Work Experience Programme. They found no female role models here. *" I was attached to a male engineer. There were no females around in this company."*; *"it got so terribly boring sitting in that office, alone, the entire day, with no one to talk to."*
- Many relied on their friends for support in the mathematics classroom (17).
- All learners spoke of their mothers having little success in mathematics
 - 7 mothers had dropped out of school
 - 12 Mothers had chosen not study mathematics at secondary level. Including the 7 above.
 - Mothers seemed to understand, sympathise and relate to the difficulties that their daughters encountered (20).
 - Because of the mothers' history with mathematics, combined with the difficulties that older female siblings might have had (5), mothers appeared to have lower expectations of these girls (5), those in the Middle and Low Groupings indicated their mothers sense of pride, with typical comments, *" none of us could, at least you're trying"*
 - An older female sibling's performance, was used by mothers as an indication of this girls' performance.
 - Those with sisters that had done well, particular to the High Group, felt pressure to succeed and emulate their performance n (3)
 - The mothers of the Lower Group, especially, were happy that their daughters had chosen mathematics but did not pressurise their daughters to succeed (5). They expected their daughters to encounter difficulty (5).
- 5 learners in the High Grouping found that at times their fathers could assist them with concepts that they had difficulty with, *"My dad loves maths"*.
- All learners indicated that they receive full support for their mathematics learning from their parents.

Discussion

The mathematics department at Ridgepark College is staffed entirely by women. When asked about role models all the girls indicated, that the only women that they knew of, who were involved in mathematics, were their teachers. 3/5 girls from the Low group indicated that they drew strength from the fact that they had female teachers. Only 3 females, from the High Group, chose mathematics and science related engineering companies, in which to complete their work experience programme at the end of grade 11. Their impressions related to the job being, very solitary and they felt they needed people around them that they could relate to, *'you sit alone in this office all day'* (Girl 9 – interview). No one wanted to teach mathematics. It should be noted that teaching, among these girls, is thought of as a profession competing with other high status, high paying professions in technology and science. This seemed to conflict with Koballa's (1978) study which suggested that girls taught by female teachers are more committed to mathematics and science careers than girls that are taught by male teachers. What female teachers helped with, in this study, was showing the girls that despite the hardships that they encountered in mathematics, there were females who had succeeded, *'I feel proud when I look at my teachers, they have succeeded in a very difficult subject'*. It was without a doubt, that the girls in the Higher Grouping were motivated in mathematics because they modelled their efforts on their female teachers. I know that they often tried to solve problems exactly the way that I would do them; they even managed to sound like me. Finding the solution to a challenging problem, or successfully completing an assignment always ended a jubilant, *'that was great!'*, started by me and eventually bought into by everyone.

Persuasiveness of peers and other siblings, relating to mathematics performance, courses and career choices, played a definite role. Their peers and older sisters were a large part of their decision to study mathematics at Grade 9 level, *'all my brothers /sisters studied mathematics to grade 12, I didn't think I had a choice'* (Girl 7 – interview). Not choosing mathematics then, could be related to perceptions of failure. The older siblings in particular, seemed to influence post –matric studies as well. In at least two cases, girls were pursuing degrees at which their older sisters had been successful, *'my older sister did a B.Comm, and I think I'll do the same'* (Girl 7 –

questionnaire). None of these learners were pursuing mathematics or mathematics related degrees at graduate level, none of their siblings had and none of their mothers had.

The home environment is crucial to encouraging success. Through conversations with girls it has been my finding, that it does not have to offer mathematical expertise, but it has to show the girls the value of their participation and success in mathematics. 7/20 girls indicated that they could ask their fathers for assistance. Their fathers projected an image of confidence that assured them that perhaps the problem could be solved. Seliktar (1998) confirms that female students have been found to be three times more likely as males, to indicate that their fathers had importantly influenced their attitudes towards mathematics.

Every learner spoke of their parents support for them in mathematics in terms of, financial support when tutors are required (12), when study aids had to be bought (20), transport to and from extra lessons (20). For extra lessons after school or during holidays, parents were always available to transport their girls and would even pay a classroom visit. While parents do offer support, they also need to drive the need to be successful in mathematics. Presently, they appear to assist their daughters feelings of inability, *'I understand (your poor mark), mathematics is hard, try your best'*, sounds like resignation and the lack of taking control of projecting the need to be successful in mathematics. Parents need to see it as a gateway to prestigious, higher paying careers for their daughters. The attrition of girls in mathematics begins a lot earlier than for boys, when parents begin to accept that their daughters will not be as competent in mathematics. The active support for girls from primary school mathematics, where stereotypes are reinforced and internalised, has to begin earlier, with the emphasis on the concurrent societal advantages of success, particularly if we wish to address equity in terms of the socio-economic imbalances of South African society. We need to emphasise the importance of success in mathematics and the value of working cleverly, as opposed to harder. Mathematics performance, is unaffected by poor resources if, the enjoyment of mathematics can be inspired and the importance of success in mathematics, can receive emphasis from all fronts.

The only prospect of a mathematical life that the girls knew of as possible, for females, was teaching. There is an absence, in industry, showing where mathematics is usable or the provision of female role models that are working in mathematics. None of the tertiary institutions ever present their mathematically active female components. Girls are unaware of the possibilities that exist in mathematics- 20/20 could only think of their teachers involvement. It was apparent to these learners then, that women could have little or no place in mathematics careers. Those women in mathematics are seen as the exception and not the norm. No learner could name a female mathematician. There has to be some form of co-operation between women in mathematics related practice and learners at schools.

5.3 Choice

In this section I examine the choices that females make about mathematics at different stages of their lives. All girls at Ridgepark College can choose mathematics or opt out of mathematics completely, at the end of grade 9. Before that, mathematics is compulsory for all girls. I have again categorised them, as I wanted to see how the different groups exercised this choice. I was particularly interested in the role that socialisation played around mathematics and the value that was attached to mathematics.

5.3.1 Related to why Females Choose Mathematics in the Secondary Phase.

	High (8)	Middle (7)	Low (5)
Choosing Maths in the School Curriculum	<p>The subject package choice offered Maths or Typing (8)</p> <p>Enjoyed Maths -scored high marks (3) despite not liking the teacher (2).</p> <p>My parents insisted I take maths (8)</p>	<p>The subject package choice offered Maths or Typing (7)</p> <p>Enjoyed maths in Grade 7 and scored high marks (8)</p> <p>My parents insisted I take maths (7)</p>	<p>The subject package choice offered Maths or Typing (5)</p> <p>It was a choice between numbers and words - numbers had more appeal. (2)</p> <p>My parents insisted I take maths (5)</p>

	<p>My siblings had done maths (5)</p> <p>Mathematics is essential for entry to my tertiary study path (5)</p> <p>Every career is linked to and dependant on maths (5)</p> <p>Would recommend Maths to other girls (5): But only if they were not struggling (1)</p> <p>Maths teaches hard work and discipline (2)</p> <p>You have got to like maths or you will lack determination (1)</p>	<p>My siblings had done maths (5)</p> <p>There is a stigma attached to girls that don't study maths - they are perceived as dumb' (5)</p> <p>Would recommend Maths to other girls (8): she needs to be logical first (1)</p> <p>Problem-solving has relevance to life -you use the skills in life (1)</p> <p>Maths broadens your common sense (2)</p> <p>Not if its not necessary for her career, 'why endure the pain and suffering?'(1)</p>	<p>My siblings had done maths (5)</p> <p>Essential for career (7)</p> <p>Would recommend Maths to other girls (7)</p> <p>Only if they have a good teacher (1)</p> <p>Only if essential for their career choice (2)</p> <p>Would not like anyone to feel 'useless' as she sometimes does in mathematics (1)</p>
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Discussion

The school curriculum, the courses that schools make available, the options that it makes open to females correlates directly with the choices that they exercise. All these girls thought that the choice of mathematics or typing at the end of grade 9 was really no choice. They would choose mathematics against any other subject. Simply by the choice made available, if we examine the codes that were imposed on these females, it presents a stark reality: if you were not good enough at mathematics, you

did typing. Convention will have you then, linked to careers that would not be investigative or scientific, considered as valued by society.

In other, co-ed schools, would typing also be offered to boys, who were perhaps not coping with mathematics? To counteract the redundancy of the typewriter by the computer, the school has offered Hotel and Catering as the option with Typing, against Mathematics for next year. Still in my opinion, a reinforcement of a very sexist stereotype. Decoded: We must prepare females for a life of domesticity or general office duties. As alternatives, the mathematics of: entrepreneurship, finance, and tourism. Areas earmarked for development by our provincial administration. Choices that involve a specialised mathematical base that would give females skills that are relevant and demanded in the development of this province or South African society with a mathematics base that can be developed and specialised further, after school. All females need to have prerequisite mathematics base.

All learners, despite their category recommended Mathematics to all learners that had the choice. The believed strongly in it having strong utility value for life in general, for tertiary study in particular, for it's teaching of logic, common sense and hard work and discipline (20). In all their propagation of school mathematics, there is a conspicuous absence of 'what then?' after school. None see mathematics as an intrinsic part of any career. Mathematics would operate on the periphery of any career, be a small but controllable part of a specific career (e.g. adding the budgets of the hotel, where one girl in the High group planned to work) for which a limited few skills will be mastered. From all of their responses it seems that that, is what the essence of Mathematics is to them 'skills mastery' for specific contexts. They view mathematics as a body of facts, that has already been established, the components of which they will call up, if it is needed, in their specific fields.

None looked at Mathematics with the potential for creation, as an endeavour in which normal people could engage and develop. As a forum for discussion and debate, a platform for multiple truths and realities. To them mathematics operates in a very removed and separate part of their psyche. This is what contemporary research calls the 'othering' of women from mathematics Secada (1995). 'Who really works with mathematics, apart from teachers?', I asked them. 'Real mathematics' is removed

from the realities of their every day lives and only used by 'white, male, professors at universities, who bother with things we will never have to understand'. This apparent lack of identity with mathematics, by the entire female sample can be seen to confirm it's patriarchal ownership and its somewhat removed identity from the lives of female learners.

Education can only be seen as equal when all learners are given the same opportunities for participation and performance. At present, very clear disparities exist as shown in Chapter 4. Seeing mathematics as an objective truth, detracts from the human pursuit and endeavour in it's construction. These girls chose mathematics, in grade 9, considering its value to their future careers (5), their previous performance in mathematics (20), their interest in mathematics (20), and the way that they perceived mathematics to be useful to their lives (20). The last aspect is where social pressures dominated the choice, 'there is a stigma attached to girls that don't study maths' (5). Garret's (1986) study confirms these factors as influencing subject choice. Eccles (1985) brought in the strong emphasis on socialisers, which confirms strongly what this study has shown. These girls (20) thought at the outset, that they could do well in mathematics. Friends influenced them, siblings, parents and teachers and they were very conscious of gender role stereotypes. While the majority do choose mathematics, they choose it with expectations of immense difficulty and the offer of limited choice in careers in mathematics.

Emphasising the value of success in mathematics, learners will improve not only their level of participation but also the level of their performance and increase the scope with which they view their choices of careers in mathematics. Particularly, girls that may not be performing well would feel compelled to improve. All 20 girls spoke of success in mathematics up to grade 9, but their performance slumped after grade 9 (14). This itself is a thesis on it's own.

The girls seem to lose confidence in their mathematical ability in junior secondary school and they perceive the value of mathematics to have decreased, '*the first test I wrote in High School I got a 'C' (shocked)*' (Girl 9- interview); '*I loved maths in Primary School, I don't know what happened in High School*' (Girl 7- interview). In high school, the Low group in particular, associated mathematics with '*pain and*

suffering' (Girl 14 – questionnaire). This contributes to whether they will choose advanced mathematics later on.

Schools need to play an active role in the image of mathematics that they give to females, they need to challenge and transform stereotypes that exist in mathematics that disadvantage females and not reproduce them. Instructional patterns that work well with girls involve, encouraging females to continue with mathematics, the testing of female learners at least once a week, the acknowledgement and reward of creativity, and the development of basic skills. Campbell (1989) observed that (schools) contribute to the faulty perceptions about who does mathematics, to the identification of mathematics as masculine. Secada (1995) cautions, as emphasising girls problems can also be counter – productive lending support to mathematics as a male domain. Girls need more to see that mathematics is something that people of their gender do and can be successful in, ‘ *I don't know of any females as mathematicians*’ (20) and ‘ *If a female wants to try (maths), I'll feel proud, but it wont be easy*’ (Girl 5 – interview), are the flawed and influential perceptions that need to change. Campbell (1989) showed that girls, who are not accepting of traditional roles, have higher mathematics achievement than girls with more sex-stereotyped roles.

5.3.2 Choosing Careers

Here I examined the choices that the girls made with respect to their careers. I looked at some aspects that influenced their decisions and the role that the school played in bringing them to this point.

Career Choices	High (8)	Middle (7)	Low (5)
Career Counselling	Received (8)	Received (7)	Received (5)
Work Experience	Participated. Engineering firms selected (3) Hospitals (2), Hotels (2), IT company (1).	Participated. Non-maths options: Hospitals (3), Vet (1), Accounting Firms (2), the Airport (1).	Participated. Non-maths options: Radio Station (2), Journalism (1), Public Relations Companies (2)
Further Study	Not maths related (8)	Not maths related (7)	Not maths related (5)
Career Choices	Management, B.Sc- Health Sciences, Information Technology, Computers, Hotel Management	Hotel Management (2), Pharmacy (1), Radiology (2), Chartered accounting (1); Air Hostess (1)	B.Comm (1), Medicine (1), Nursing (1), Computers (1), Broadcasting (1)

Discussion

Career exploration is a developmental stage identified by career development theorists (Super, 1990). The learners at Ridgepark College are exposed to a variety of career options and counselling for their entire Grade 11 year. Technikon's, Universities and private colleges target the school, from the beginning of the year, in their recruitment drives. This aggressive marketing I believe, is on the assumption that these middle class learners, would be able to afford tertiary study. Further to this, we have a well-resourced guidance centre that has information on most tertiary institutions. The difficulty that I have with the Universities in particular is that they give a very

generalised presentation on what the university offers. The public relations person hands out relevant information, invitations to open days and departs. I compare this to Universities overseas, where university faculties exist and receive funding that's dependant on the number of students that they recruit (Washington State being one such university). These universities have thriving mathematics departments and mathematics related programmes. The academics are involved in presentations about their areas of specialisation and in addition, the faculties normally fulfil gender and race quotas. In terms of mathematics, our most crucial neglect is that we do not promote it actively to females. *'If I studied mathematics, where would that lead to?'* was a frequent question that the girls asked.

Institutions would tell you why that qualification in Information Technology (IT) or Marketing is so important, but our career directing is done in the absence of gender representation and equity. It lacks a view of the broader social picture. Engineering for example, to females at the school, has never been promoted. Perhaps the school needs to pursue these presentations or institutions themselves can challenge sexist stereotypes by targeting females for previously male dominated mathematics and science related qualifications. The learners in the sample, have the opportunity to investigate various career options and then select a company where they could explore their abilities and interests further, in a two week Work- Experience-Programme, slotted into the grade 11 school calendar. In learning about these careers they also learn about themselves.

Much of the literature suggests that girls limit the options from which they can choose as careers. For example Kahle (1990) found that girls seem to have fewer out of school mathematics experiences compared to boys. The girls in this group in particular have learned the roles and occupations that are 'appropriate' for them. From all their career choices, mathematics appears to be studied as an auxiliary course for degrees that stipulate mathematics as a requirement eg. B.Comm. B.Sc. as supported by statistical data in Chapter 4. At least three of the High Group, I would call 'exceptional' at mathematics. They are able to think independently and creatively and yet are not choosing mathematics or related paths. This seems also a concern of National Science Foundation (1991), who found that girls with exceptional

academic preparation in mathematics are choosing careers in this area in disproportionately low numbers.

I asked the captain of a ship once, if there were any females in the world that could navigate a cruise liner such as his? I found his sexist reply repugnant and him, a loss to be speaking to. Can we not navigate the seas or skies? Improve, build or invent the machines that do? Build skyscrapers or study the skies? These questions were discussed every morning for the first term, during a programme I had instituted for my class, with a view to challenging stereotypes and self-imposed limitations following the analysis of this data. Despite this, the sample has chosen study paths that are not typically male or female. The Middle and Low groups chose careers and work experience that did not challenge stereotypes. Those girls (3) in the High group, that chose traditionally male occupations for work experience, viz. Engineering, found that they did not enjoy the time spent at engineering firms. *'Boring'* and *'too little interaction with others'* were comments that these girls had given in their evaluations of their work experience. None of them consequently, chose these as study paths.

When men and women exhibit the same behaviour, that behaviour is devalued in females (Leder, 1996). Women are frequently penalised for attempting participation in the male domain. While men are called ambitious, assertive and independent, women that attempt the same are labelled aggressive, pushy, and argumentative Pearson (1987). It is these covert socialisers that inhibit female choices. Sex bias was defined (Diamond, 1975) as *'any factor that might influence a person to limit --or might cause others to limit-his or her consideration of a career solely on the basis of gender.'* We have to examine influences from the environment, culture, early socialisation, traditional sex role expectations of society, home versus career conflict, the experiences of women as part of a particular social, ethnic group. The majority of the sample belonged to families in which their mothers were employed, those that were not, could not find suitable jobs but wanted to work. The mothers that were employed were in jobs that did not challenge the existing sex- role stereotypes. This notion was common to all ethnic, racial and cultural groupings in the sample. These girls had no experience of the alternatives. This despite not one learner or their families prescribing to the stereotype that *'a women's place was at home'*. Women

in South African society are very much a part of the work force and are expected to contribute to the economic level of their families. The Unilever Institute of Strategic Marketing at the University of Cape Town, in the Futurefact Project 2000, recognised the following as a predominant trend of South African society

- that women enter the workplace and despite marriage and family commitments, most continue to work.
- that many married women continue to work in response to the high cost of living in order to supplement the family income.
- that women in informal settlements and rural areas are increasingly forced to become breadwinners as a result of retrenchment /inability of males to find employment, abandonment by males /divorce.

The question that begs is not whether or not women will work, they will! But at what levels are they being employed?

From the 20 autobiographies, parents seemed supportive rather than prescriptive (though it would be difficult to capture subtle pressures that may have existed within the families). Supportive in that they acknowledged and offered encouragement to their daughter's choices. *'My parents will support me in my choice'*, was a common comment. No one indicated that their parents were prescribing their careers. I think that parents have to play a more active role in encouraging their daughters towards higher paying and prestigious occupations that seem reserved for males. Our society needs to see women as higher-level managers (CEO's), actuaries, physicists, statisticians, mathematicians, engineers, astronomers and technicians. Career socialisation has steered girls away from these and other mathematics related choices, even though they did not choose conventionally female options. The girls in this study in the main don't think about advancing in mathematics, because they have no idea how to use it in their adult lives. Skovsmose (1994) uses the expression 'mathematics is formatting society'. This study suggests that we actively pursue and expose this information, with a view to redress and equity and to format society to take into consideration female needs and choices, so that females are not forced into existing formats.

Chapter Six - The Mathematical Autobiographies

The stories of women's lives are intrinsically bound to their mathematical lives. There can be no telling of one without the other.

Regina, 2002

This chapter is a deeper encounter with females, who have been successful in mathematics at least up to Grade 12. I have included myself as part of the data, and have placed my mathematical life story first. I begin with my story because it was initially used as a stimulus for inspiring and exemplifying what the girls could write in their biographies. We all experienced this writing exercise as rejuvenating and therapeutic. The very clinical, goal-directed atmosphere of the mathematics classroom seldom allows for individuality and expression. This exercise permitted that, and the writings of the girls compelled me to re-think the objective reality that I once perceived mathematics to be. We engaged in a process that sifted our mathematical experiences that captured powerful similarities and intriguing differences.

Their writings have been edited, so as to omit information that the girls did not want disclosed and to present as well as I could, their thoughts as a coherent story. The paragraphs have been numbered to facilitate and assist the discussion that follows. A unique script represents each. I have to once again record my gratitude to these girls for their frank and very honest disclosures and for their time and effort in a very pressurised year. They gave of themselves in ways that far exceeded my expectations and have taught me far more than I could ever have taught them.

This section afforded an opportunity to distil broader themes to explain mathematics participation, performance and choice among successful girls in mathematics.

6.1 Our Mathematics Narratives -The Stories of 6 Successful Females

- | | |
|---------------|--------------|
| (a) Regina | (d) Robyn |
| (b) Gaylene | (e) Karushni |
| (c) Fortunate | (f) Lynette |

(a) Regina - My Story

My earliest recollection of an encounter with the word 'mathematics' was in my first year of formal schooling. A much older girl spoke of preparing for a 'maths test' that day and being afraid. Confidently, I replied that we had also made 'mats' out of grass that week. Needless to say, after she stopped laughing, she patiently explained that the work that we did in Grade 1 involving numbers was called 'Mathematics' or 'Maths'. I can only empathise with the poor children in Grade 1 now that have to deal with MLMMS. (Imagine the associations that they will have to make, definitely none as pleasurable as my 'mat -making'). (1)



As I grew up, I recall my father constantly saying that Mathematics was his favourite subject at school and that he had always done well at it. Now, I analyse his motives as recognition of the psychological power of suggestion or perhaps, the truth. (2)

In the 1970's, the schools were not racially integrated. My classroom would have been a sea of little, exclusively, Indian faces. The School was called a 'State Aided Indian Primary School'. Mathematics in Primary School took me through the motions of learning the basics, the rules. "When dividing fractions, invert the second number and multiply", we (Std 5's) had sat for a few minutes prior, deciding what to do with division, we rote learned and chorused our multiplication tables and were punished with a sharp smack if we got them wrong. Grade 6 (then called Standard 4) reminds me of WH Auden's words, '*minus times minus is plus, and the reason for this we need not discuss*'. To us this appeared normal. Apart from these, there was no single incident, good or bad that I can recall. (3)

In secondary school, Grade 9 and co-ed, I made a conscious decision to enjoy, and do well in Mathematics. Little did I know at the time, that my mathematics teacher had just lost his only child, a daughter in a tragic drowning. He related to and taught the girls, in particular, in a very distant and uninvolved way. My efforts craved his affirmation initially, but then, in it's absence, I began to look to myself. Also there was satisfaction to be found in beating the boys in my class. (4)

My enthusiasm for the subject saw my marks improve to the top of the class. The final Grade 11 Mathematics Paper 2 is reserved as perhaps one of the warmest memories of my life ... I completed in half the time, and couldn't find a single question on which I could've lost marks. My teachers buzzed

excitedly...my friends congratulated and celebrated with the silent and me but admiring glances were stimulus for a growing girl. (5)

My matriculation year, I worked really hard. A traditional, conservative Catholic upbringing ensured that I was aware of my home, school and religious responsibilities. I produced good results and that facilitated my career choices to anything that involved mathematics. Former House of Delegates schools were not allocated guidance counsellors and teaching appeared the only option if I wanted to continue to study mathematics. Definitely, I felt at a university, than a training college. If there were other options in mathematics, a university would offer it. (6)

I am teaching now, it is good to be back in a classroom. I thoroughly enjoy the children. I am grateful everyday that a child thanks me for making the effort for them to understand mathematics. In my teaching, this is perhaps my most desperate quest. Few colleagues had studied Mathematics to university level, and frequently requested assistance with problems. This is the mathematics that I enjoy. I still however, consider myself to be very much, a learner of mathematics. (7)

FINIS

At the completion of my story, I read it to the girls and allowed them to question me on it. They related well to the feelings of happiness that described how I felt when doing well in mathematics. They also applauded the idea that I resisted being defined by societal conventions and having the courage to choose mathematics when few girls would. This provided the catalyst to their writings and so began their exploration...

(b) Gaylene - My Life Story

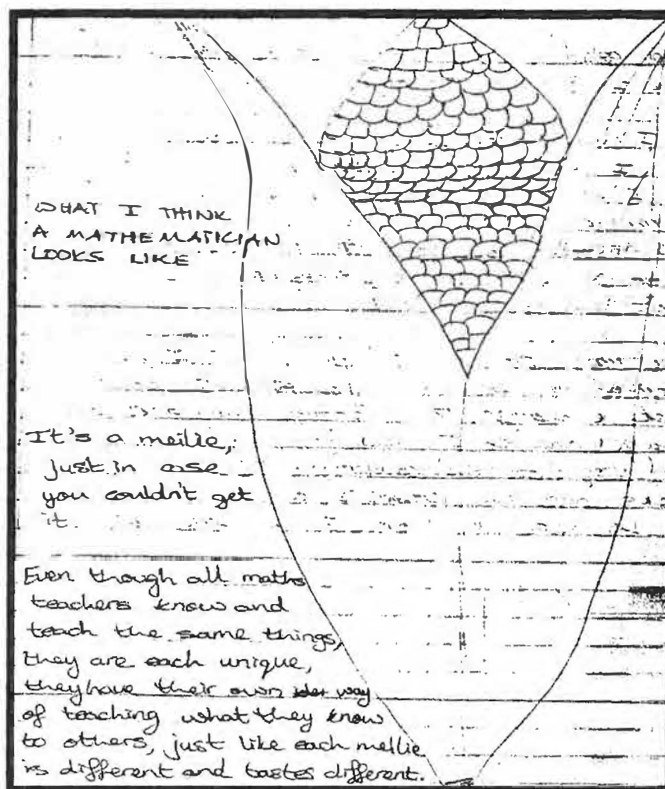
On the 19th of August 1983, at about 10:30 am I arrived, quite adamant to make my mark in this world.

My family and I have lived in the same house since my older sister as born, which was a year and five months before I was born. We are a very Christian family. (1)



My parents know that the most important thing in a family is love and spending quality time together. We love holidaying and have been to the USA and UK. Just before my matric year, we went to London. Being at an all girls school meant that I started dating quite late, at 15 ½. I feel that boys are a waste of time. I'm concentrating on my schoolwork and friends this year (2)

My drawing of what a Mathematician looks like...
It's a mealie!



I was talking with friends and thought this was the perfect way to draw them. Even though all maths teachers know and teach the same things, they are each unique, they have their own way of teaching what they know to

others, just like each mealie is different and tastes different. (3)

When I finish school I want to go into the hotel industry. I want to do Hotel Management. I think I would make a good leader and would run a very good hotel. I would love to study overseas, but I can't so I will probably stay at home and study at the Royal Hotel. By the way, did I tell you that I have been accepted as an exchange student for a six-week exchange? The Rotary Club does the exchange and so I will hopefully be off to the USA (they chose the country) in December for 6 weeks and the person I am exchanging with will be here in Jun/July. Cool huh! (4)

My Mathematics Life History

The choice of subjects at the end of grade 9 was typing or maths. Not really a choice! I knew I would do maths. An experience that I recall is, Writing my first maths test in high school and getting a C and doing the same thing in grade 11 when we got the "new" teacher who loves to set hard tests. (5)

I Love maths and consider myself successful because I usually get an 'A'. I just have an amazing ability to comprehend physics and maths better than most people. I get that from my father. I wouldn't recommend that all girls do maths especially those who don't like maths or those that are failing. But for other girls then yes I suppose you do kind of need it in your life. Maths encourages you to think laterally and not only logically. What I don't like about maths is that they teach you a lot of unnecessary stuff that you never need in life even again. I'm going into the Hotel and Catering industry after matric, I will never use the maths that I have learned. (6)

I loved maths in primary school and did very well. I think in High School I suddenly did really badly in Maths and I got such a shock and I went 'Oh my word what is happening?' I realised that I would kinda have to work harder in High School so I started working harder and I did ok. Algebra comes naturally to me, but Geometry I have to work harder. (7)

My father has been the most influential in the way that I think of maths. He always had done well in Maths and he always helps me if I get stuck.

If I look at maths and its usefulness to me...only as background knowledge that you need to have for life in general, but in terms of what I want to do as a career

choice its not necessary although the Hotel School says that they would prefer us to have Maths as a background. There are techniques from Algebra that I can use, but Geometry NEVER!

(8)

You hear so many things about matric maths that you think that you will never make it. But, I love being good in maths. I think people tend to respect you because you are good at something. Especially people that you work with - they look up to you and they ask you for help when they get stuck and are afraid to ask the teacher. I've never really missed having boys in my class, I don't think that they can affect the way that I learn -I did very well in primary school with them in my class.

(9)

I did receive career counselling and attended many career workshops. I was usually guided towards the business field. At the end, I decided I wanted to eventually own and run my own hotel, boss people around and be in charge. I could never be a Secretary - we used to as little girls say, "Oh dad can we be a secretary? ..." and he would go, "No ways - you had better do something with a bit more sense than that"

(10)

Women that are in mathematics, I think definitely they have a lot of courage to be there because that field is very male dominant. I think it would be very scary to go into a group of men and be the only woman. It could be quite difficult for women because you are competing with men who seem to think they are the superior race for some unknown reason.

(11)

When I think about a mathematical world, I always think about professors, teachers or scientists. And I couldn't be a scientist sitting in a lab by myself, even if I am bossing other people around - I just don't want to be confined to a lab with just those people that I work with and not having any communication with the outside world.

(12)

My older sister was also an 'A' student, she is currently in her second year B.Comm. My mother is a computer teacher at the moment, she has her masters in town planning, but when she had kids she kind of stopped town planning and never went back to it. She was a principal of a pre-school and a teacher at a pre-school - now she is back doing computer training. My dad is an electrical engineer. My mom wasn't exactly one of the brainiest in Maths, that definitely came from my father but she thinks Maths is important to have as a background knowledge before you go into the outside world and onto University.

My dad loves Maths - he thinks it is a brilliant subject; he encourages everyone to do it .He thinks that everyone has no excuse to be failing Maths because it is not too difficult.
(13)

I enjoy the Maths classroom because I am doing the work rather than the teacher - in the other classrooms it's normally the teacher. The only anxiety that I feel in maths if, I haven't done my homework or if we have a test. English and Business economics stresses me more. I don't study very hard for Maths at all. I just go over examples ...I never learn Maths.

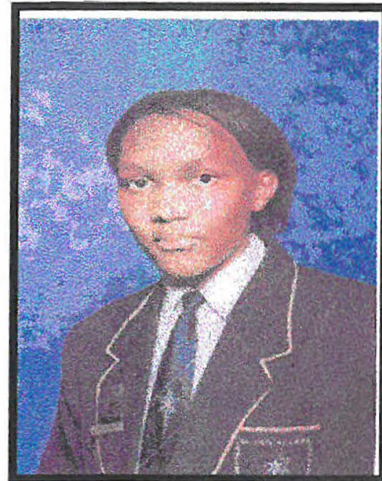
Many girls fail maths because they don't care whether they pass or fail, it isn't necessary for them in their lives. A lot of the time they just can't grasp the content.
(14)

Finis

(C) MY LIFE STORY

Fortunate

My name is Ngobile, but most people call me Fortunate. I am seventeen years old and am currently in matric. I was born in a place called Kwa-Mashu on the 12th of January 1984. I was born to a family of three girls, I being in the middle. My parents are both teachers. I've been to three schools throughout my schooling career



The first school I ever went to was Malalisa (a school my mother used to teach at) when I was just four years old. I must have coped really well because I was placed in the first position in my class. I then went to Duffs Road Primary School- a whole new world for me. For the first time I had to speak English even outside an English lesson. That problem, however, I soon overcome and everything else just fell into place. The down side to this school though was, the long walk my sisters and I walked home. Then I moved to Springfield Hindu Primary where I would attain my standard three.

And now here I am in Ridge Park College, in matric. It's not so much hard work as it is a load of work. And it does not help when my relatives tell me they are anxious to see my results in the paper in January next year. It just reminds me how many expectations I have to live up to. (1)

My worst fear now is not being accepted at the University of Cape Town. This is because although my parents have put aside money for me to attend a University, it was never in their plans that I would choose to go outside KZN. With all the travelling fees as well as accommodation, my only resolution is a bursary. But recently I received the bursary application form and the criteria there is to pass maths on a HG, with a B symbol. Clearly that is way out of my league. Maybe it was my destiny to never go to UCT. But then again that's life, whoever said it was fair. (2)

My Mathematics Life History

When I chose maths in grade 9, I wasn't sure which career I wanted to do but I was sure I didn't want to do anything with words so numbers were my next option. I don't consider myself successful in maths. I don't consider maths difficult because I am female, like any boy I have a brain, the ability to see and hear, so no difficulties! I know my best in maths is a C; I'll just do my best to pass. And it's not really a case of persisting because I believe I've given up altogether, as I've learned the hard way that my best is not enough to pass let alone do well. (3)

Between grade 9 and grade 11 I had a maths teacher that I was terrified of. I never asked her for further explanations from fear. I therefore would recommend maths to any girl provided that she had a good teacher. I feel positive when I understand a section from the start; I know I will manage the rest. Yet, Higher-grade maths, doesn't question what you know but (mocks) how little you know.

I loved maths in Grade 9, Mrs. Labrook, I remember scoring 80% on a statistics test I had a lovely teacher and she was very inspirational – she really taught individually – she would go with the weak learners from all grades and stuff and she was really good with me. In Grade 10 because the teacher wasn't sure sometimes herself – most of the time she was corrected by Gaylene or she would leave and go to other classes, I lost interest. I thought maybe it is a hard thing if my own teacher doesn't understand.

(4)

I think there is so much pressure because everyone in my family wasn't good with Maths – my father didn't do it at all, my mother was terrible at it and my sister never did it in Matric because she wasn't good at it. I was like the first person to have done it. Maybe I thought I was good because I was the only person who understood it to that level in my family. My father was most influential in my choices in maths. Both my parents had never studied maths. With my sister they understood that she was terrible and not going to choose maths. My dad encouraged me. His view is that it's hard work but it pays off in the end. My mum would be biased because she really found it hard – on the one hand she will be saying hard work, and then on the other hand, if you don't understand it there's no way you can. Both parents offer me much support they provide a tutor and are happy to buy any books that I may need.

(5)

Maths is a lot of hard work to succeed. I do see potential in myself – I work hard for the exams – I know I could have done so much better than I did for Geometry because I had worked hard. Maths has been the hardest subject in my life and I would be very happy if I did well. Maths is a vital subject if you consider doing a B Com degree as this entails the counting or basic calculations of money. There is not many women in careers that require mathematical skills. I am planning on doing B.Comm afterwards and that entails a lot of Maths. At present, I use maths in cooking. You have to measure stuff you have to know exactly how much to put in.

(6)

I did receive career advice and have read many books. I always wanted to study B.Comm. And be an accountant. I would admire any woman in the maths or science field, as I know it couldn't have been easy. I know, I would definitely not be a chemical engineer. Mathematics is an exciting subject I just think that I have a really very shaky background and foundation to it and that is why I don't like it now. I don't feel more anxious in the maths classroom...it's more anticipation, I wait for something that I'm not going to understand.

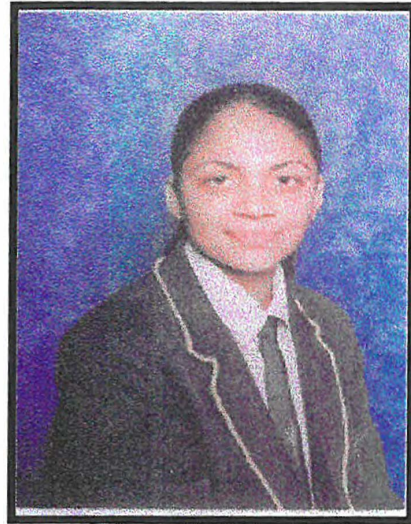
(7)

(d) INTRODUCING ME!

Robyn

IN THE BEGINNING ...

I was born on a cold Sunday morning on the first day of April in the year 1984. I was the first child born to my parents, Richard and Priscilla. My dad named me Robyn Leigh - a name that means "Shining Fame". I had an enjoyable childhood, being the only child for 4½ years before my mother had her second child. I was always a daddy's girl. My grandparents were a couple affected by the "Marriage Act" during Apartheid, and had three children before they could finally marry. My grandfather was even put in a prison for this. (1)



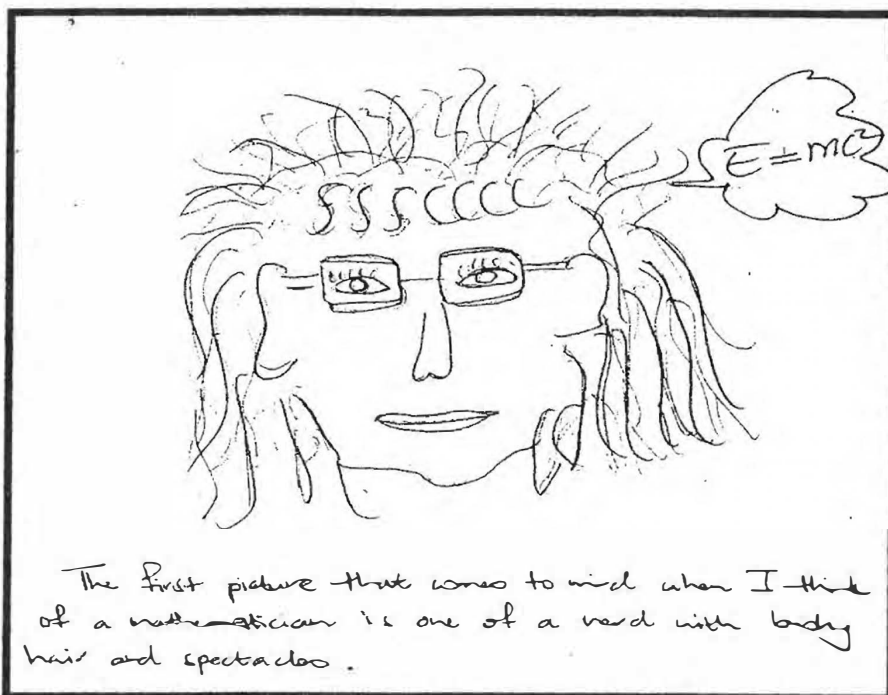
THE TWO GREATEST WOMEN IN MY LIFE ...

My grandmother, Cynthia Grewan, was diagnosed with cancer on her 60th birthday in June 1996. To see my granny, Cynthia, who was more like a mother to me, die slowly to this monster was the most painful experience for my family and I. My granny died on the 4th of February 2000. I was there that afternoon. Everything seemed so unreal. I come from a very religious family. We all strive to follow in her footsteps and live lives that she would have been proud of. (2)

My mother, Priscilla never had the chance to complete school, as she came from a poor family. She started working at the age of 17, and hasn't stopped since. For a woman who has no real education, she has done really well and I am proud of her. She is the Supervisor of the Bookkeeping Department. I love her because of all that she has had to sacrifice in order to give us whatever we need, and even most of what we want. My parents were divorced in August of 2000 after being married for 17 years. This was a painful process for us. (3)

This year, 2001, I am in matric. I aim to not just pass, but pass well in at least 3 to 4 A's. Ridge Park College has become home after being there for almost five years. I love school. I intend to pursue a career in either the management field or to attain a Bachelor of Science degree and thereafter specialise in a particular field, which I haven't yet decided. (4)

The first picture that comes to mind when I think of a mathematician is one of a male, nerd with bushy hair and spectacles.



My Mathematical Life History

I chose Mathematics, as I believe that every career at some point is directly linked and dependent on one's mathematics skills and abilities. The experience that most stands out in my mind is from the November Examinations 2000. I, along with many other girls, failed my Geometry Paper. It was my first time in my entire life failing an exam.

I do consider myself successful at maths... I don't get B's or A's, but I've managed to pass and stay on the Higher Grade whereas most of the Maths students in Grade 12 are on the Standard Grade. (6)

I do try hard in Maths. I do my homework diligently and sit with my exercises and work at them and I manage to solve them. Also, from my teacher's advice, I have all my theorems and equations stuck on my wall. In this day, I constantly have to look at them and this helps me learn. Maths is a subject that is very important for any career that you might want. It teaches discipline and perseverance. Maths is not a hard subject. It is a subject that simply requires a lot of extra work and determination. (7)

I like Maths because it challenges me and allows me to have to think and work really hard. Unlike other subjects, you can't merely study from a textbook, and this for me is the best part. Anything that you achieve in Maths is through hard work and effort on your part. I dislike the fact that during class work exercises and homework, I can do really well. I understand and I find it really easy solving problems. And yet, during tests

and exams the sums become so complicated and a lot of the times cause students to fail, that I think, is really unfair. What's the use of doing so well in homework and the exercises if you are failing the tests and exams? If I could I would change the fact that such a big part of the syllabus is made up of Geometry. In everyday life, Geometry is practically useless. I don't see why studying certain figures should be so important? (8)

I'm not quite sure what career I'm going to pursue. But, I do know that out of the options that I have, Maths on the Higher Grade is very important and is a big help. In almost every career package, Maths skills are required. Possibly, information technology or optometry. I have never come across people who say that they are going to purely study mathematics after school -never once. I think maybe someone like that would go into lecturing at a university or would want to be a mathematics teacher. (9)

I enjoy being at an all girls' school I actually find that compared to males that I know I do much better at Maths. Males seem to experience more difficulty in Maths. The only role model that I have is my teacher. At school, obviously my maths teacher- I have never met a teacher who is more, in love with what she does. And coming to school everyday and having someone who says isn't this a beautiful equation, or obviously that gives you a lot of motivation and wanting to work harder because she loves it and she is working hard at it and insisting that you do so it does give you that boost to want to work at it. She is so passionate about the subject, She make me want to do my best. She gives so much of her time and energy into making Maths a subject that I've come to love. I love Maths and the challenge that it presents. I love trying to solve different problems because I like the feeling of triumph once I do solve it. My constant effort and hard work, I think, makes me more successful than a lot of others. My mother always would encourage me - she hates to hear I can't do it or I just don't know - she always says there is no such thing. (10)

My mother says that every field that you go into you have to have Maths or anything in life that you do always goes back to Maths .My father - he agrees with that. My mother never completed her schooling - she left in Standard 8 - it was mainly through experience of working that she learnt a bit about Maths and accounting. My father did maths till Matric and afterwards majored in English and History .My father encouraged me to take mathematics. I

was doing so well. He can't really help me with my Maths, my sister; in Std 5 he knows the basics for fractions, decimals. My mum didn't actually give me a choice; she said definitely you would take Maths! And now my parents are very supportive. (11)

My Maths learning in Primary School. I didn't really enjoy it - I hated fractions. I had a good Maths teacher, enjoyed being in the teachers lesson, the subject becomes a bit more interesting and you work a bit harder. But I know that I hated fractions and I hated the story sums with the factions ... (12)

In secondary school, in Std 6 or 7 we had a Mrs Knight who took us for Maths we were still like the 'A' class and we used to do well in Maths. But if she asked a question and no one new the answer she would start throwing tantrums. The one day she asked us something and everyone kept quiet, so she picked up the duster and flung it at us and said 'well you are supposed to be the A class - give me an answer' and she sat down and refused to teach us because we did not know the answer. It is something that I have never ever forgotten. (13)

I love Maths whether I am getting an A or a B. I do because it poses a challenge and I love being able to come into a Maths lesson and if I am not understanding and then I do get it that is like a that is a victory for me - you don't want to leave once you got the hang of something - so I love Maths and I love working out the problems and getting the hang of things and I like to take time out on my own to teach myself also about Maths. I think Maths is useful all the time, I mean everything around us whether you are at home cooking or baking or using a recipe there is Maths involved. So it is always - I could never see anything without Maths. (14)

If I go into something like IT then you have to have a good Maths background - I mean dealing with computers and that's a very technical subject and Maths I think is a basic in a lot of the technical subjects and careers as you go into and then if you look in the university books the main requirements in everything, no matter what you are doing, is mathematics. I did receive a lot of career guidance and especially because of the subjects that I take I get a lot of advise from friends who are engineers or teachers. I feel a woman in mathematics or science is someone who can be admired .As part of this changing society I would definitely admire someone who can go into the Maths or science field. Someone who will maybe say to men well, we can do it to because times are changing. But

men still have the same mindset, so I would love to be able show them a woman who is in that field, can say well, we can do it to! That maths is a male domain - society gives you that view and men give you that view - you stick to the kitchen and stick to teaching and whatever else, leave the civil engineering and the rest of it to us - but I don't see it that way. (15)

I definitely would not choose Engineering - because I hate physics, it is not a very easy subject to cope with - you either understand it or you don't - I think even if you study you can still get there and not have a clue on what is going on so I wouldn't have something that is too that has a lot of physics involved. In maths it's a lot of understanding and being able to think on your own because you can learn in the classroom, but your teacher cant teach you everything - you have to be able to have some initiative and thinking on a broader scale on your own. (16)

I enjoy Maths, so I have a positive attitude towards Maths. I know I can do a lot better if I go that extra mile. I know I need to pull my socks up. I don't think anybody can do badly in Maths, if you really try hard and put your mind to it because as I said earlier, it is just takes thought and understanding the work. You have to do extra work - you cant just come to class and learn in the lesson and not go home and do the homework or not sit and work the things on your own. I have my things stuck up on my walls that I look at everyday. When I am turning off the lights there are my theorems, and there is my absolute values and everything about it. So you have to do the extra work and think about it every day or remind yourself. You cant just let things lay and then pull it out. You have to remind yourself all the time so it is constant work. (17)

I would definitely tell anyone who is going to make the subject choice, to choose Maths. A lot of people are negative towards Maths but Maths is an enjoyable subject. I mean it is a challenge yes, I know that for some people its harder than I think. Yet, sitting and paying attention and working at it is all that is needed - who knows who may be the next mathematician. (18)

(e) My Story

Karushni

I've been through a lot in my short 17 years and I've been affected and influenced in many different ways. I've faced a lot of sorrow and live by the all or nothing rule, mainly because I'm so used to doing things only halfway and leave things incomplete.

I know I've got potential and if I bothered trying, I'd do well. I'm not sure if it's because that I, myself am not fully interested in Maths and all other aspects of



school or that I'm the type of person that only works well in a warm atmosphere and when I know my results will be pleasant. That's one of my problems. (1)

Born on Sunday (Easter Sunday) on the 23 April 1984, my name was chosen through Hindu tradition. My father chose my name Kar - because he loves cars. It is Sanskrit meaning "The Purest". They had my sister and six years later, they had me. I've always wanted to be loved and still seek only happiness in life. Everything else really truly is irrelevant to me. My parents divorced when I was six. My dad was the first man in KZN to get custody of his kids. He has always been proud of that. He has always been proud of us and has boasted our achievements. My brother was excellent in all the subjects and my sister was fairly OK in Maths - I think she got a C. My dad - definitely promoted Maths, he really wanted us - there was like no choice about doing typing or anything else. Besides, I plan to study accounting and need to study maths. My dad studied maths to university level; he thinks it is very important at school and to life afterwards. He is always ready to help and if he can't, will get me the help I need. (2)

Friends have always been my inspiration. They are my whole life, my reason for continuing. They are my happiness. I am an awkward person who was almost trained to not show my emotions, but I love my friends. I wonder what qualities they see in me. When I assess myself and my achievements, I disappoint myself. But I set myself no

goals and no expectations so it does not bother me when I do not succeed. If I were to upset someone else by doing this, then I'd probably work harder so I am not the cause of their sadness. (3)

It is just that sometimes even if I motivate myself and concentrate on my work, I just cannot think. I guess I get depressed if my work is not right. I've changed slightly. I pick myself up and try a little more. I still can't work everything out, but most works out well. I've tried to convince myself on the importance of getting a good matric mark. I really do hope to succeed and shine bright.

My grandfather – he would not stand to see me this way.

My friends – I don't want to let them down.

My teachers – They seem to be disheartened recently, with the attitude they receive from their students.

My children – I don't want them looking back and seeing their mother as a failure, a non-achieved, an ungrateful lazy slob. (4)

My Mathematics Life History

Maths or Typing? Typing was not an option.

The best times in the maths class are when I know the answer and am called on to give it. I loved Grade 8. My teacher's name was Mrs Bovey. She was the best. Understanding and good humoured. But we respected her for this and she used to set us work and leave. We used to talk, but concentrating hard on our work and knew the time for serious work and play. I don't consider myself successful in maths. I do do well in some sections. I consider myself average. I find it very demotivating when I try and don't succeed. Having said this, I would recommend maths to other girls—it broadens your common sense. There is nothing more satisfying than getting the answer to a challenging problem, or understanding a concept that other girls are struggling to understand. I also enjoy not having to write long essays. (5)

I don't like the fact that maths has the power to dishearten me.

Sometimes I just can't see the point to what is being done. My teacher inspires me, her excitement motivates me and makes me want to do well. She makes me want to feel the happiness she does, when she sees a difficult / challenging sum. She makes me want to challenge them too. She makes me want to achieve. I want to have naturalness about maths like her. Why I want to succeed in maths...wanting to believe that I am as good as those who do succeed. Wanting to feel worthy of my teachers attention. Wanting to please secret wishes. Wanting to conquer. (Even if I'm running into a brick wall!!). know she'll probably be there. With a bulldozer to get me through. Wanting to not disappoint those who believe in me. Proving that I am just as good, Or that I at least persisted, never gave up and carried on trying.

(6)

The primary years I was pretty good in Maths. In Std 7 I started getting a bit bored with it and so getting a bit slack. The teacher used to always ask me the questions because I used to love it a lot. I always used to do the homework and always get all the answers she used to always ask me to you know check with her. I loved that! Now I rely on my best friend, she and I do our homework together and support one another. For both of us there is no bigger thrill than doing well at something.

(7)

The career guidance that I received directed me towards advertising, human resources and management. Recently, a lot of women have become more interested in man -based jobs. If a woman feels that she is smart enough and she wants to succeed I think she should go for it. A lot would depend upon the company that she is going to go into-how they will react to her. The job that I would definitely not choose is a medical doctor-the hours are too demanding. I don't know of any women mathematicians, maybe they put down women or maybe not many women have been interested in Maths before like they are now. So far though, nothing has hindered me in maths .I find that to learn any thing I have to understand it first.

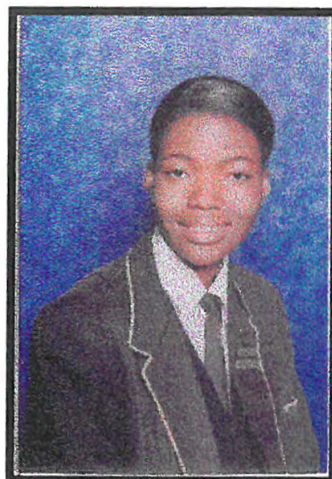
(8)

(f)

My story

Lynette

On the 21st of May 1983 my family was blessed with a cute little girl who was named Linea Lynette. Born in the well-known King Edward IX Hospital. (1)



At the age of five I attended Sydenham Crèche. Being with other race groups was strange to me but more uncomfortable because I could not utter a word of English. At the age of seven I attended Bhekilanga L.P. School, which is situated at KwaMashu M Section. I remember the classroom being very full of children. My parents felt that a change of school would be good and my English needed to be improved. After grade two I was accepted at a primary school at Newlands West called Briardale Primary School to do Grade three. Because of my poor English I had to repeat Grade two. This is the school that built up my confidence in speaking and writing, my self-esteem. I met with different race groups which I grew learning a lot about their cultures. I took part in debates and was very active in sports. At Briardale I achieved a lot of awards and trophies. In my last year I was voted Deputy Head Girl of the school, sports girl of the year. In 1997 it was my first year attending Ridge Park College. This school is far from home. I remember sitting on the bus that morning, and thinking how smart I looked in my new uniform. For the first time I was in a big school with older learners than I was. I was very nervous on my first day wondering if the children would like me or not. I was amazed by the amount of work but most of all, the rules and the silence during lessons. (2)

My mom is a Nurse and an Educator at a Nurse's College. My dad is an owner-driver at Coca cola. I have three sisters and a brother. Gugu a nurse at King Edward married with three children. Pinky who is a Personnel Officer at Illovo. Nana a teacher at Empangeni and my brother doing his second year at Technikon SA (IT). Then me.

Both my parents have studied maths to matric. My one twin sister Pinky - she stood out in Maths but the rest no, they didn't. Yet, they encouraged me, after grade 9 to choose maths rather than typing. My dad's views are that Maths is a hard subject but you need time and understanding for it. You must always practice Maths in order to succeed in Maths. My mum also thinks that Maths is a hard subject because I think that she had problems with Maths, when she was doing Maths but she also encourages

me a lot and not to give up .My parents offer tremendous support to me. If there is tuition for Maths they take me there - and they buy me study guides. They feel that people that can think do maths and they respect this. (3)

My Mathematics Story

I chose Maths at Grade 10 because I had two choices either Maths or Typing. My marks in typing were never above 20% whereas I always gained above 40% in Maths. I also need maths to get into the medical field. I try to do my best in Maths, but I sometimes give up easily. I need to work harder. I feel every girl has to study maths. I feel motivated that if other girls can do well in maths then so can I. In Primary School Maths wasn't that hard as it is now and I enjoyed Maths in Primary School - I was good in Maths. I especially liked our Maths teacher. I found Maths in secondary school had got a bit harder. The sums got complicated, harder. I prefer algebra to geometry. Sometimes I just can't do it! (4)

My teachers have been very strong influences when it comes to my feelings about maths. They show an excitement to tackle problems and I like the way that they do things. I think Maths is something that you have to understand. You need to think in order to do Maths. It is a thinking subject. I find that in everything you do, you have to use maths. There is little that you can choose to study that does not require maths. I want to study dental therapy or medicine. (5)

I think maths is about understanding because if you don't understand Maths you will never get a sum right. Maths is completely different to learning for Biology. In Biology I don't have to listen in class I can always go home and read over my notes and I'll understand them. Maths if I go home and try a sum I don't know the method I won't understand anything - it is different. To me Maths has become harder from Grade 8 Maths - was easy - but as I got to Grade 9, Grade 10, 11, 12 it got harder and I had to understand more. Maybe its because I don't pay much attention to Maths or I lack that interest now. End. (6)

The Africanising and Feminising of Mathematics -

Synthesis of Themes that Arose from Analysis

The learner narratives, that the reader has been through, felt to me, very much as though I was an on-looker into a colourful and vibrant plot. As a teacher of mathematics, we are seldom invited to share in the lives that are woven around, and by, our learners. As a researcher, I felt so touched and privileged by the honest, open – hearted and warm welcome that I had received, by each of these young ladies into their lives. The teacher in me is forever changed.

I have deliberately, shown their entire stories and their responses as they had presented them to me inclusive of spelling and grammatical errors. For, while each is especially unique to the person (represented by a unique script), the themes involving their mathematical lives showed uncanny commonality. Up to Junior Secondary, all learners were certain that they wanted to participate in mathematics in senior secondary. By this stage all learners would have passed through two screenings: the first, to continue in mathematics, at this school, they had to exceed 50% in the final examination in Grade 9 or they were directed to Typing or Home Economics. The second, at the end of Grade 10, they would have to have scored over 50% to remain on the Higher Grade.

Even learners, who were not coping in mathematics, felt that not pursuing mathematics further, would stigmatise them as inadequate. Each learner brings to her mathematical experience a context that is shaped dynamically by her experiences. What was it then that made each one not want to participate in mathematics post-matriculation? What made all these learners not like geometry? How did each one see the mathematical world and her in it? Does the mathematical world itself work to exclude females from it? How? How can females that I see every day, who clearly love mathematics, who perform well, exclude themselves from mathematics after matriculation, so categorically? African females are the poorest performing demographic at school as shown in the statistics...is mathematics education racist and sexist? Favouring certain groups of mathematics learners over others? These were a few questions that seemed to predominate throughout the study.

Certainly, females are treated differently in mathematics: from the lower expectations of parents and teachers from very young to, the images that society and the curriculum provides to, the predominant pedagogy of the mathematics classroom. If what we teach and how we teach it, serves to disadvantage a very significant group of people, then allowing the problem to recur, after criticising the statistics, is compliance with the status quo. We have to examine the gender related and racist expectations in mathematics. It cannot be co-incidence that at all levels of participation and performance in mathematics: school, university, professionally, males outnumber females, and Africans are the least successful. The social, political and economic implications are thus, too vast. To hope to exact change on society is perhaps wishful, however, it is within the range of teachers to expose and control the mathematics curriculum within the classroom.

Here I will discuss the 20 learners, but with special emphasis on the six autobiographies, allowing issues/ themes that have emerged to be contextualised. You will find specific reference, in these themes, to the autobiographies. I have called the accumulation of the themes the ‘Africanising and Feminising of Mathematics’ to show that I have attempted to develop these themes alongside the needs of mathematics learners in Kwa-Zulu Natal. Allied I feel, the following themes seem to exert an a powerful and sometimes, very covert influence on the direction of mathematics education and deserve discussion:

The Africanising and Feminising of Mathematics with respect to

6.1 The Teaching and Learning of Mathematics

6.2 Women in the South African Workforce

6.3 Globalisation

6.4 Racism

6.5 Sexism

Prof. Ndabandaba (2001), current Minister of Education, Kwa-Zulu Natal, at a parliamentary workshop on education, stated that schools had to transform to produce Africans that are proud of Africa. He accused schools, particularly the more advantaged schools of integrating and not transforming. He talked of the indigenous majority being kept in perpetual subjugation, acquiring different patterns of thought, behaviour and language. He calls for an education that would liberate us and

transform us into independent men and women. His observation of society can be mirrored in the mathematics classroom. Females acquire patterns, thoughts, and language, behaviour that is foreign to them but allows them to integrate into the mathematics classroom. It is a matter of compliance and not will. They adopt these patterns by virtue of their race, culture and sex. The South African Democratic Teachers Union, provincial chairman, Ndaba Gcwabaza (2001) concurs when he talks of the need to speed up the redressing of the curriculum, particularly in African schools, where subjects such as mathematics and science have been denied the African learner and disadvantaged the few that have tried.

6.1 The Teaching and Learning of mathematics

South Africa has a rich, cultural heritage. It is a dynamic that impacts on every sphere of endeavour in our society except, the vacuum in which mathematics teaching and learning has operated in. The norms, values, beliefs and attitudes of our cultures and peoples have not impacted on mathematics, except negatively to sustain an inequitable status quo of advantage for the privileged. If we recall the review of the language policy of Ridgepark College we saw that African learners are expected to conform to new language codes, English, in our classrooms. This study revealed, that our African learners frequently made to repeat a year, if they are not successful in adopting these codes (see paragraph f (2)). All African language learners in this study indicated their (initial) difficulties with English. This study makes an important case for the retraining of mathematics teachers in the predominant African language of learners. Lessons and examinations need not conform to an African language code but the conceptual development of learners can be assisted through the use of their mother tongue. Critical nuances in the subject can be traded and understood mutually to assist understanding. It is important to see and place mathematics and mathematics education within the context of our culture. Otherwise, we apportion to the dominant culture the far too much power. In both their state of the nation addresses for 2001, both Kader Asmal and Thabo Mbeki stressed the need for improvements in mathematics and science. As mathematics teachers we but deplore the poor mathematics results in matric every year. To be silent, in whatever language is to be complicit.

African schools are notoriously under-resourced; leaving those learners that can afford to attend better-resourced schools, no option but to travel large distances to attend these schools. Fortunate (in b (2)) talks of walking these large distances a little girl in primary school. Ridgepark College is one such school-it is situated in an upmarket area in terms of property values. Few girls that attend actually come from its immediate geographical bounds. The majority of learners are African and travel from townships around Durban. In a recent school survey, in which the entire school was sampled, the average distance travelled by a girl at Ridgepark College is 60 kilometres per day at an average cost of R8 per day to attend school. Parents feel the economic impact and learners the physical impact of transmuting such large distances daily, twice. Mathematics, especially, feels the impact when learners leave their homes very early in the mornings (on average 5h30) and are unable to sustain their concentration levels through out the day. They return home in the early evening, at 17h30 on average. That's a 12-hour day, for children with ages ranging from 12 to 19, with no extra- curricular activities. To assist girls with this reality, mathematics is consequently time -tabled for the earlier part of the morning sessions to accommodate these learners, when they are hopefully 'fresher' and not tired. Again reinforcing the importance with which the school regards mathematics. The problem, however, is addressed and not solved; the girls are simply tired in another subject. How then can we address the poor matriculation results, or an improvement of existing results, if we cannot ensure equitable access to learning?

A start would be to dispel the image of mathematics as a objective, abstract, well-defined, truth, to a discipline that exhibits human endeavour, that is creative, accessible and with the potential to be personal. The learners in the sample learned mathematics, as external to them, to be good in mathematics, to have access to it, was to give up control. If they were allowed to take responsibility for the creation in mathematics, they would be able to take responsibility for it's learning and then rightfully, assume ownership of the subject. A popular resistance slogan of the 80's adapted perhaps says it best, 'lets take Mathematics to the people' and evolve even further to 'take mathematics to women on their terms, in their realities'.

The national strategy released in June 2001, to increase the number of historically disadvantaged pupils with higher-grade mathematics and science passes, focussed on

the developing of 100 successful but poor schools into special mathematics and science academies. Pretorius (2001) made the following comparisons: in the 1988 matric examination, for African students, 770 out of 11 608 passed maths on the higher grade. In 1995, the World Bank pointed out the severity of the crisis: of 10 000 African children entering grade 1, only 1 will matriculate with mathematics and science.

In 1994 /1995 Grade 7 and 8 pupils performed worst out of 45 countries in the Third International Mathematics and Science Study (Howie, 1997). In a repeat study of 38 countries in 1998/1999, the result was the same. In two studies of 12 African countries, by the Joint International Unesco-Unicef Monitoring Learning Achievement Project, South Africa's Grade 4 pupils, were rated as having amongst the poorest numeracy, literacy and life-skill competencies in Africa. In addition, in the province of Kwa-Zulu Natal, quarterly tests administered by the Department of Education to 3182 mathematics learners in poorly performing schools showed that 89% of learners on the higher grade in mathematics failed (Bisetty, 2001).

While, few learners in the sample of 20, could say that her experience in mathematics was consistently good, few could recall always liking it. They all recall having points in the syllabus when mathematics became easier or interesting, see Gayleen (b (7)) and Fortunate(c (4)) to illustrate. The idea that this study would advocate is not to invoke revolutionary change, by imposing co-operation and collaborative groups, with open –ended tasks if this is not what learners are accustomed to. This would compound the anxiety that learners experience and be detrimental to the learning process. Rather the gradual, integration into the methodology and the assessments would leave learners with the freedom to develop.

The national strategy for mathematics specifically emphasises a focus on girls-schools and disadvantaged communities. Yet, it is my feeling that we can direct resources and funding, but, until we're able to uncover what makes some very poorly resourced schools, and some English-second language learners, perform well, it will be mis-spent.

6.2 Women in the South African Workforce

All 20 girls were daughters of mothers who worked. There was little doubt among them that they would work too. Their mothers were not the principal financial providers of their families, their fathers were. The questionnaires helped to confirm this. This can be identified as an essentially middle class occurrence where both parents are employed. South Africa's economically active population is characterised by three distinct groups. On either side of this middle class are the single income families where I have observed a fascinating anomaly. Where the single income families are affluent, a small minority in terms of the entire population, it is the men that work, while women are at leisure. Yet, when single – income families live on the bread-line it is the women that work and the men that are unemployed. This leads me to conclude, that the balance of economic power lies in the hands of men. In this study, I am neither interested in the affluent nor in the poor. I want to look at the opportunities that these girls, who are largely middle class, have.

These girls have access to universities, they have resources and the know – how to apply for funding should they need it. All 20 have the privilege of being able to choose tertiary study, have been taught predominantly by female teachers in mathematics and so have had exposure to female role models in mathematics. Their schooling being a privilege for which their parents will work very hard. The picture that they see, is the levels at which their mothers and teachers are employed. Not one girl could mention a female in any other mathematics related career. Despite women forming the largest component of the South Africa workforce, there are vast discrepancies in their qualifications and earnings when compared to men. When it comes to the higher paying and status laden jobs there is a lack of role models. The message that these girls get is that society restricts the entry of females in certain spheres. Karushni points out her perception of this very nicely in e (8), '*women...in man –based jobs...a lot would depend on the company that she is going to go into-how they would react to her,*' e (8). This would not be a concern for a man. While Fortunate acknowledges that to challenge the status quo would often be '*at great personal cost*', c (7) and '*I would admire any woman in a maths or science field...it couldn't have been easy*'.

Unlike, these girls, many women struggle to get an education and are destined to receive lower wages than males. Merten (2001) in her research showed, that women face higher levels of unemployment and poverty than men.

I consider the following the main obstacles to women in our work force:

- 1) the lack of self-confidence. Gayleen admits that her '*mom wasn't the brainiest in maths*'. I don't think that this mom would handle any of Gayleen's difficulties in mathematics with confidence. Affirming the many messages that Gayleen is already being bombarded with in her numerous social interactions about women and mathematics. If a mathematics related query arose at her work place, Gayleen's mother, I suspect would defer the responsibility. Lynette's mother thinks that, '*maths is a hard subject*' and we're told that she had problems with mathematics, f (3).
- 2) the pressure of juggling roles of mother and wife and career. Many women would interrupt their careers to care for their families. Gayleen's mother holds a Masters degree in Town Planning. She put a very promising career on hold to have children, b (13). We as a nation could look at the model of social democracy through which the Germans and their Scandinavian neighbours achieved economic growth, that provides incentives and facilities that make the combination of career and parenthood possible.
- 3) the lack of resources. As discussed above for the majority of females. Robyn's mother left school in (Standard 8) grade 10, for this reason d (3).

We cannot escape the role of nurturer and caregiver and feminism does not deny us this. We have to provide environments and conditions under which women feel safe and secure. Women are a significant part in the South African economy, for them to reach their full potential, it will take business and government working in tandem, as appears to be the global trend, to provide well qualified and skilled women the opportunity to combine career with family life.

6.3 Globalisation

"We are part of a new global economy driven by knowledge and technology. We cannot isolate ourselves from this reality", Alec Irwin, Minister of Trade and Industry, SACOB banquet, 2001. The economic growth for South Africa is highly dependant on producing qualified people for industry. The South African, National Strategy for Mathematics, Science and Technology, shows the same emphasis

- Establish 100 mathematics and science schools, including girls- only schools
- Improve the teaching of English (commonly used as the medium for mathematics and science instruction) as a second language
- Allocate more than half the time to numeracy and literacy from grades 1 to 7
- Provide quality mathematics and science textbooks and other learning materials
- Introduce more bursaries for mathematics, science and technology teachers
- Re-train under-qualified mathematics and science teachers
- Conduct an audit and a needs analysis of all mathematics and science teachers.

Success in mathematics, for these girls, is owed in part to the broader school culture characterised by strong leadership, qualified teachers and motivated learners. All five girls spoke in their autobiographies of how different Ridgemark was to their primary schools. Lynette, f (2), was *'struck by the rules and the silence during lesson time*. They valued the professionalism and expertise of their mathematics teachers, see Fortunate c (4), who values a teacher that was inspirational, taught for each individual and would work patiently with the weaker learners.

Each of these girls is strongly motivated to succeed. *'.. I got a C! ...Shock...I realised that I kinda had to work harder'*, Gayleen b (7) and Robyn d (7), *' I do try in maths. I do all my homework diligently'*. In the context of the matric examination 2000, nationally, only 15% of the candidates who passed maths on the higher grade were African. *'The number of young people who study mathematics with any degree of understanding and proficiency has declined when it should have been increasing rapidly .As a result the pool of recruits for further and higher education in the information and science –based professions is shrinking. This has grave implications for our national future in the 21st century'*, Kader Asmal, Sunday Times, August 5 2001. The pass rate at Ridgemark was 26/33 (79%) for the same examination. We are doing something right; we are giving 79% of our girls the opportunity to be

selective about their career paths. They have the potential to play the global economy.

Yet their career aspirations: hotel manager b (6), accountant c (7) and e (2), Information Technology d (15) or Optometry d (9), Medicine f (5), hardly challenge the bounds of convention when it comes to sex role stereotypes. Even I, became a teacher a (6). Mathematics is involved but to very specific and limited degrees and will only be studied as a prerequisite for their preferred degrees. Us girls, will never be blamed for any nuclear disaster or falling bridges!

The importance of mathematics and science particularly among females has very strong emphasis, if we as a country are to become global players. Yet, schools, like Ridgepark, continue to teach what they taught 20 years ago and in the same ways. Our girls pass, but lack a global vision and seem not to believe that they can make a significant contribution, even if it is only to choose to challenge the status quo. With successful and advantaged girls such as ours, selecting out of higher paying, more specialised, mathematics related fields it is little wonder that, our corporate and economic globalisation has led to the redistribution of wealth in favour of the already powerful and rich, while the economic and social disintegration of the marginalised, women a large component of this group, continues. They will all most likely remain middle class (luck aside) in the economic stratum.

Like other global economies, we need a new economic model that promotes the values of justice, equity and the inclusion of the disadvantaged. In legislation we affirm women, but the effects are hardly visible to girls such as these. The international trend is for life- long learning among workers. The challenge is for every female to make herself continuously employable. Schools need to transfer theoretical knowledge as well as nurture, retain and develop intellectual capital in line with a global vision.

6.4 Racism

The Indigenous Women's Network, at the Third United Nations World Conference Against Racism, September 2001, Durban, South Africa, defined and discussed racism as *'the systematic application of racial and ethnic bias through social mechanisms of power (policy), which oppresses and subverts the culture and political systems of the indigenous to the benefit of the group that controls the dominant society. Racism is perpetrated and implemented by and through governmental policy, the policies of economic regimes (business and labour) and other social structures including educational, religious and judicial systems. When racism is encoded in governmental policy, and in societal norms of behaviour and belief it is called institutionalised racism'*.

Education in South Africa was used overtly as a tool of oppression of the majority of indigenous people pre-1994. Since our new democracy however, the education policy and practice of mathematics education have not kept pace with the transformation. Historically, African females have always performed poorly and continue to do so. The redistribution of resources has been prioritised, but, without sound pedagogical basis, largely it remains money and effort that perpetuates rather than alleviates the shocking statistic. The learning of mathematics by females demands attention.

In examining the females in the sample of 20, I found that racism manifested itself in very discrete and underlying ways. The school previously belonged to what the government called Model C schools. Racism in South Africa ensured that all race groups were contained in their own geographical boundaries. Model C schools were established in previously White urban /suburban areas. This meant that females from other race groups had to walk considerable distances to school or rely in the majority of cases, on public transport. This entails added effort and cost for the African girls. Many learners, particularly African girls spoke of walking vast distances to their schools in their autobiographies, Fortunate in c (1) and Lynette in f (2), as well as being tired at the end of the school day. The school is fed by the majority of learners that are resident in the surrounding townships of Durban. They rely on taxis and buses, are affected by work stoppages in the transport sector and the ever-increasing costs, Fortunate elaborates in f (2). The school accommodates where it can, by

providing transport fares for females that can't afford it, has arranged mathematics for the earlier sessions of the day, when girls are not so tired. These efforts are commendable as a means to address racism, in acknowledging the difficulties that some of our learners have because of where they live, because of their race. However, very subtle forms of institutionalised racism, do occur, where our African learners are expected to conform to certain standards that they may have difficulty meeting. The one already discussed, is the use of African languages, which is not allowed except in the IsiZulu class. These learners are thus exempt from certain nuances and understanding. The second is that the school understands a family to comprise parents and children that live together in the same house. Increasingly, I have found that many girls are the primary care givers to their younger siblings. Their parents provide and pay for their accommodation, food and schooling expenses but reside in areas that are out of Durban. This affects the girls when school forms are due that call for parent or guardian signatures. Who signs for them? The consequence is that girls (in mathematics) detained after school, for one hour, for non-compliance... will have to make alternative transport arrangements, bear the additional costs, and return to their household responsibilities an hour later. Institutional racism can be silently pervasive.

Mathematics of the Western tradition has been used in the perpetuation of the continued disadvantage of black females. Indigenous people have not had the chance to contribute to modern mathematics. None of the girls in this study could name an African mathematician. This is an abuse of the power that mathematics wields because it subjugates a people. These females learn that their ways of knowing and their indigenous knowledge are somewhat inferior. The possibility for them to be at the forefront of mathematics understanding is nonexistent. They learn this from multiple influences of parents, teachers and friends. We need to teach that there is no inferior or superior, to eliminate racism. Access to knowledge means power. Mathematics appears to have validated racism where an elite group (white and male) has denied access to the power of the knowledge. Indigenous females are under-represented in the fields of mathematics and science, these fields having the most influential and authoritative positions in society. We need real efforts that engage and keep female learners participating in mathematics.

'We should be building ties that unite us across racial divides. Given the variability of societies on this continent, generalisations about African beliefs tend to oversimplify an extremely complex reality if they are not properly contextualised. Traditional communities is a term that is grossly abused in SA, conjuring up an image of stasis and backwardness' De Haas (2001). Acknowledging that racism exists and that it has profound and tragic consequences is the first step to counteracting racism and the impact that it has on its victims. We have to look at governmental and private sector policy that perpetuates racism. *'We cannot and should never subject our children to any discrimination on the basis of their social class and even their social origin. This is more important in a country that is still largely characterised by vast inequalities'* (Asmal, 2001c).

The resolution of the problem of racism is to first, review the history of mathematics second, to re-evaluate the philosophies of mathematics to understand why some philosophies are considered superior and others are not and third, to provide access to indigenous people to contribute to the fields of mathematics. The expectation held by teachers of non-white students in mathematics is often low in d (13), students see their efforts in the subject as pointless in c (3) and they have experienced failure so often in the subject that they are convinced that they cannot do it f (4).

Similarities exist between gender and racial attrition from mathematics; there are factors that are different for non-white students. The schools that they attend are usually primed to fail. Low income and socio economic factors are cited for their failure. Teachers tend not to blame the teacher or the school but the child. Rather, than continuing to make the child fit the system, that we know is designed for white middle class students, we need to alter the system to respect and encourage children's differences while preparing them to survive and succeed in a society that could be at odds with their cultural values. Ability grouping, streaming as already discussed, dooms the majority of non-white students to low achievement and lack of educational opportunities, that drives them further to the disadvantaged status (Oakes, 1985). We have to acknowledge that we learn mathematics differently, because of who we are and where we come from. The mathematics classroom is being blatantly racist in assuming everyone equal, we simply are not.

6.5 Sexism

'The culture and traditions of all nations are harder on women. To me it seemed that being a woman was a curse. I wish I was a man. We give and nurture life. We are the weaker sex and we are abused by society...for women the shadow is both darker and closer. Even in our civilised world, it lurks behind them, always threatening them, like a dark evil bird; a stranger, a friend, a madman, a father. Even a husband can hurt and humiliate them as a matter of right' Khuzwayo (2001).

Women behave in a social/cultural context where being male or female makes a difference to life in general and to career choice in particular. In many parts of the world, women remain repressed and oppressed at a number of levels. Gender stereotypes reinforce this repression. Women remain underrepresented in leadership roles, which means that their perspectives do not enjoy inclusion. Mathematics is assumed to be a gender-neutral discipline (a (4)) but operates in a male dominated culture of knowledge and produces and reproduces cultural stereotypes in women. Women make up just half of the world's population, yet, historically, they are disempowered and disadvantaged, largely due to repressive structures analogous to those operating in race, class, sexuality and age. There is a definite socio- cultural context where being a man or a woman makes a difference to your life. In mathematics, women continue to work in a profession shaped and run by men and largely without their input.

We need to look at the status of women in society, the issues of power between men and women, both in public and private. Gayleen b (11), felt, *'that it must be scary to go into a group of men and be the only woman'* and that *'it must be difficult to compete with men who seem to think that they are the superior race'* from Robyn d (15), who further contends that *'mathematics is a male domain and that society and men give you that impression'*. The gender summit held August 5 – 8, 2001 examined strategies for achieving the ideal of gender equality in society and ways to maintain an effective program to make South Africa a non-sexist society. Among the themes discussed: discrimination against female learners, access to justice, women and the economy. Gender equality is increasingly, being recognised as a national concern and not just a female concern.

“All education must contribute to the improvement of the quality of life for all South Africans. Education must be rooted in the reinforcement of respect for our humanity and dignity; it must gain sustenance from the need to ensure equality and non – discrimination in our society; it must underscore the right to life. In short it must be geared to ensure that we teach each other as human beings” Yacoob (2001).

Increasingly there are efforts to redress gender inequalities. Policy makers, leaders and women are letting their voices be heard. To hear would mean to assess the way we think as women, the limitations that are self-imposed be removed. The way that the girls think of mathematics reveals their innate insecurity. Fortunately (6), ‘*maths has been the hardest subject of my life*’. Only one girl in the entire group felt that mathematics came to her naturally and that was Gayleen. The rest all spoke of hard work and difficulty, and their mothers were also associated with these feelings. Their fathers were more confident, able to assist even if they had done mathematics a long time ago. Many signals that we receive and send reinforce these messages that females will not easily cope with mathematics. We have to dispel the myth of being unable because we are female and the myth of segregated careers for males and females.

The cumulative effect of the themes above serves to emphasise the proactive stance on the part of our society and communities have to take to transform. These efforts have to be bolstered by continuous moves to eradicate all forms of racism and sexism in our classrooms, homes and interactions with one another. Females especially have to legitimate the cause, because of their subjugation in terms of gender, by lending their voices and challenging the patriarchal structures that impose.

The next chapter, will contextualise the forces that exert influence on the way that, these girls have participated and performed in mathematics and the choices that they have made regarding the subject. Further the chapter will develop a case to strengthen mathematics in a transformation context such as ours. The conclusions of the study will be presented and the resultant implications for teachers, our female mathematics learners and future research, will be expanded.

Chapter Seven - Research Conclusions , Implications and Limitations

Where the girls are in mathematics.

7.1 Mathematics Development – Contextual Forces

This study suggests strongly that mathematics serves as a race and sex filter. This study has shown that we can safely estimate the races that will excel at all levels of mathematics learning and we can predict, safely, the sex of the group that will pursue mathematics careers. Most girls will choose mathematics at school, certainly up to the junior secondary phase. Certainly the 20 that participated in this study, found mathematics enjoyable up to that point. They found in their classrooms a white, middle-class orientation, where teachers dominate classroom practice and the emphasis is on content rather than context. It is my feeling that such practice predominates in mathematics education, as it does at Ridgemark College. Mathematics takes place in the context of the culture, of both the school and the larger community. Norms, values, beliefs, attitudes and behaviours impact on the nature of mathematics education and the equitable access to learning. This poses special challenges, especially as classes become an amalgam in terms of race, ethnicity and culture. Cultural messages can be accepted, mediated, decoded or resisted. Largely this study has examined, the dominant perceptions of gender- related expectations within mathematics.

If we examine mathematics as a cultural product, then we can accept that mathematics is a creation, a negotiated meaning, a dynamic not static process that is continually shaped and reshaped by individuals and their respective cultural contexts. Accepting the above premise means that the cultural context can be consciously changed, to better and more equitably respond to the development and empowerment of girls. We therefore need to encourage girls to participate in mathematics by challenging and exposing the paradigm that prevents their further participation and hinders their performance. At Ridgemark College, the site of the study, the number of girls that are

opting out of mathematics has more or less doubled in the last three years at grade 10 level, from 19 girls to 33 to 78 in 2000. I explain the decline by referring to this middle class orientation that mass teaches mathematics clinically, and, on the pressure on schools to produce good results. A poor pass rate in matric would not attract the successful types of advantaged learners that these middle class schools actively pursue and recruit, to maintain their standards and hold on to their practices, and to justify and continue with their fee structures.

I have noticed that the majority of girls start off very excited about choosing mathematics in Grade 10. In my classes I have encouraged girls to be more autonomous in their mathematical learning. I have attempted high level discourse interactions with them, provided almost immediate positive feedback for their appropriate strategies and have attempted to build independent and divergent thinking. This comes from my understanding, that they are not the problem. They spend an hour with me a day and generally five hours in other subjects where the convention exerts itself again. Even, I am forced to succumb sometimes, when administrative pressures impose, and resort to teaching, via lecturing, girls what they have to know. This serves to exclude females from mathematics, increase their levels of passivity and reinforce what a tremendous amount of socialisation has already done, stifle female participation and performance.

Policy and practice needs to address the low levels of achievement and output of females in the system. We need to be able to focus on and develop those females that show potential, with a view to increasing the number of graduates in mathematics. Presently, educators have few opportunities for the development and sharing of innovative teaching strategies. All teachers that I had opportunity to consult with in this study were unaware of gender-related differences in the learning of mathematics. Educators need to be developed and given time and support. The exciting off-shoot is that, each teacher would function with the duality of researcher in the classroom as well: examining and reflecting on teaching, trying out new and innovating strategies, refining facilitation as opposed to controlling the classroom dynamic. The Lego Action Model, that comprises a learning situation where learners draw on one another strengths, eliminates aspects of control and all learners are seen as equal partners in learning. I believe that teachers need to provide opportunities for females to become

leaders. The wide range of abilities and interests of learners has to be catered for, where those that are able to study mathematics must intensively be catered for and incentivised. The Auditor General in a report highlighting the severe shortages nationwide, particularly of mathematics and science educators discussed a survey in the Free State which showed that only two of eight colleges trained teachers in mathematics and science. The Auditor General tabled the following recommendation in Parliament: '*Bursaries be made available to students studying 'essential subjects, Mathematics and Science'*', Daily News Monday, 28 2001, pg4. It is these proactive gestures that will lure girls to mathematics and science. There is tremendous status and power that the study of mathematics offers and to those that succeed there are tremendous rewards in terms of well paying fields of work and study. My interpretation of equity, would mean all girls are given the same opportunities to learn mathematics and that they all treated equally.

Within this, the curriculum is not innocent in reproducing disadvantage, purely because the way that females experience mathematics is different. That all girls in their autobiographies indicated that they didn't enjoy geometry could not have been co-incidence. It has been my experience that girls lack certain spatial skills, avoid taking risks, and are more afraid to be wrong. We have to devise ways that allows girls to develop these skills. We as teachers have to constantly seek practice that will provide all girls with the opportunity to learn mathematics. Recall the anxiety that was peculiar to the Low and Middle categories when it came to examinations and tests. The contexts in which mathematics can be embedded can be strange and intimidating to female students. Equity is achieved through all children having access to the mathematics they need to learn (they shouldn't be excluded on the basis of language for example) and, to the means of demonstrating this learning. I regard my educational task to be to improve curriculum implementation, to draw equally on all girls learning experiences, to provide supportive learning environment. To encourage the participation in mathematics and assist females in developing greater levels of performance. Experience has taught me that learning experiences need to draw equally on the learning styles of children from different social groups. I have noticed that African females are forced to learn mathematics, which is less consistent with their experiences and interests, cultural practices and developmental sequences. As a school, as the mathematics team, we need to think who school mathematics is for,

what it is, what should be learned, by whom and when. We need to validate female's own knowledge and experiences, with respect for diversity and difference.

Mathematics constructs the mathematics learner as a gendered subject: middle class and male. Girl's successes are hard work, conscientiousness and rule following rather than real understanding and 'brains'. Only one girl thought she had an amazing ability to learn mathematics, the others all felt they needed to work hard. We need to teach girls to be aware and critical of the hegemony so that they are aware of their positions in mathematics. Females need to be engaged in the mathematics to bring about social and economic equity. They need the knowledge and tools to understand how their attributions and choices in mathematics are socially constructed and constrained. They need the knowledge and tools, an understanding of the nature of gender and power relationships and how mathematics is implicated in perpetuating inequalities in these relationships.

7.2 Mathematics Development in a Transformation Context

The most common refrain in studies on education in Africa is crisis. South Africa's poor and working class look at schools with the hope of mobility from their dismal conditions. We hope that schools start everyone off equally. Parallel, the autonomy of teachers is becoming increasingly constricted in terms of the interpretations of the curriculum and administratively. Teacher development, empowerment and co-operation have been the rhetoric for centralisation, standardisation and rationalisation.

In South Africa, in particular, results of national examinations are dismal and education authorities are at a loss about what to do. This study showed that the participation of female learners in mathematics has shown levels of increase nationally but the attrition rates of females in mathematics remains dismally low, compared to males. We need to provide high quality mathematics to all learners of mathematics by improving our teaching capacity to deliver quality mathematics.

The 20 girls of this study have shown that girls at all-girl's schools are more confident in their ability in mathematics. They loved mathematics, the challenge of a problem, and the satisfaction of a solution. I think we need therefore, to make the mathematics and science option attractive to girls and offer incentives. A good pass in mathematics should be followed with preferential access to universities mathematics and science schools. This in my opinion would be in line with the principles of affirmative action and equality and redress.

That mathematics is made compulsory up to grade 9, in the General Education and Training Band (Dept. of Education, 2001a) is encouraging. It is hoped that all girls, even those that choose to exit at that point will be mathematically literate and competent. The new curriculum statements while they acknowledge gender inequalities and stress the teaching of values (Dept. of Education, 2001c) are conspicuously vague on elaborating, revealing a path for educators to follow. However, the teaching methods, outcomes and materials that should be under the control of the practitioners are put into the hands of the education departments that ignore teacher input and do not reflect on the implications of their prescription. This enforces apathy on teachers whose skills atrophy and disappear. There is the consequent decline in initiative and morale. Certainly all teachers at Ridgemark express reluctance to be involved, with Curriculum 2005, in grade 8 and 9. A vicious and destructive cycle if we consider that the majority of teachers are female (who this study links with directly affecting the participation of females). If historically, we examine all occupations that are defined by female labour they have been subjected to these conditions. The goals of using mathematics to prepare students for real life is not only a partial fiction, but it institutionalises as official knowledge only perspectives that benefit the groups that already possess power in society (Apple, 1995). We have to ask who benefits? Will males continue to be the group favoured in terms of participation and performance?

Defining education as 'practical' severs the connection between daily activity and critical understanding. By limiting school curricula only to the practical problems of daily life, the skills of critical reasoning are left to those already in power (Jones, 1989). We need curricula that empower us to be socially critical and a pedagogy that empowers us to change the social strictures. A Vygotskian perspective, which is a

thoroughly social understanding of the 'situatedness' of human knowing in my opinion, should be adopted (Vygotsky, 1986). The South African education situation is one that we best understand, and solutions cannot be adopted from other countries in the hope that we will improve on our problems.

7.3 Conclusions and Recommendations of this study

This study has compelled me to rethink my assumptions that all mathematics classes are homogenous and ungendered, that everyone can be treated in the same way. When I examined the national statistics for mathematics participation, I was encouraged to find that the female participation ratio was increasing over the last 4 years. However, where I had assumed we were running effectively i.e. at school the participation numbers were sharply declining over the last three years in terms of more girls are opting not to choose mathematics. We moved from 30% of the total population passing higher-grade mathematics in 1998 to less than half that at 13% in 2000. Ridgepark, like most schools, analyses its results for that specific year and these cumulative declines are undetected

The girls in this study indicated a need for an environment in mathematics where they are able to communicate and support one another. 15 girls in the group indicated that they relied on the support of their friends who often brought them clarity when they did not understand concepts. Classroom organization does not frequently encourage a co-operative atmosphere. Perhaps a useful exercise is to ask females to draw impressions of their mathematics classrooms. In my current practice there is little space to expand beyond the scope of a very specific mathematics syllabus. Girls are taught what to do and seldom how to think mathematically. We need to create an atmosphere that encourages independent thought and problem solving.

No girls, in the group of 20, knew of any role models, besides their teachers, who were involved in mathematics related careers. This, in my opinion, plays a vital role in discouraging girls in mathematics as they feel a lack of identity. We need intervention programmes to give girls a glimpse of industrial and mathematical work through the eyes of role models. Partnerships with the community could provide

girls with role models and the glimpse of mathematics in use. South Africa has no database or directory of mathematically successful women and this study has been the impetus for me to start one. To see the levels of participation and performance of females in mathematics increase, and to give females a more expansive choice in terms of mathematics careers we need to see women in mathematics and science as the norm and not the exception.

Further, despite a copious amount of information regarding careers, in the absence of the unpacking of gender, race and cultural issues, these learners, would exercise choice in the restrictive parameters in which they are comfortable. As the data shows, females will participate in mathematics at school level, though these numbers are decreasing, they still remain under male participation in general. The performance trends of females also in general appear under those of males, where fewer females appear to pass in mathematics compared to males and this trend persisting to university, where more males graduate with mathematics related degrees. There are consequently, fewer females in mathematics related careers. Females watch the way that other girls are treated in mathematics at school, at university, in the work place and they then make the decision to be involved or not. At school, the impression that is created, is that mathematics is difficult, particularly at Ridgemark College, this directs girls away from the subject.

Teachers can create mathematics environments that encourage female participation and risk taking. Encourage amongst young girls activities that encourage visualisation and spatial skills. Reject sexist stereotyping, buy a girl a chemistry set and not a Barbie doll was a popular drive on American television in 1999. Certainly, the parents in this study need to be less accepting when their daughters experience difficulty in mathematics. Their empathy should incorporate measures that would seek to correct. A car that experiences a break down, is not discarded or regarded as non- functional forever, but is fixed and improved. Mathematics can be 'fixed' is an attitude that parents need to adopt. Mothers, in this study, were too accepting and this allowed their daughters to resign themselves to levels of poor performance. Collectively we can assert that females are capable of any job that they may choose and provide examples of men and women that are working in and with mathematics. Non - sexist language has to be developed and encouraged and the language of

aggression (kick, take a stab at it) discouraged amongst both boys and girls. In my classes I have translated the word “man” to mean both man and woman. The intent was to break down communicators that frequently reinforce gender stereotypes. I have taken special care that texts and problems do not reflect or encourage sexist stereotypes.

The level of stress in the mathematics class, these girls indicated it around tests and when they lost understanding, needs to be diminished to increase the transmission of knowledge. Over the last two years, I have acknowledged to them and exposed the ‘messiness’ of mathematics – that there are uncertainties and limits to mathematical inquiry, that questions have to be asked. I have found that providing the girls with the material for the next day’s lesson encouraged participation and built self-confidence. I gave them freedom to make connections between what they already knew, what they are learning and the world outside of the mathematics classroom. We acknowledged many solutions and pursued and admired the most elegant. Also, the questions started to flow and the mathematics class was no longer as quiet as Lynette remembered it (f (2)).

This country has inherited the vast discrepancy between the advantaged and disadvantaged. It has to develop a sense amongst the advantaged that their prospering could have rippled the consequent disadvantage for other citizens. We need to develop a social conscience that makes us wanting to receive in the context of giving. Private schools were responsible for 11% of the higher-grade mathematics passes in the matriculation examination 2000(Statistics South Africa). I would like to suggest, at the very least, that for every Higher Grade matriculation mathematics class, every private school be compelled (by legislation, if necessary) to admit 1 female African mathematics learner from a disadvantaged community, to complete matriculation at the school with all costs borne by the school.

This partnership between private and public schools can extend to the development and training of African mathematics teachers, with inadequate or no mathematical qualifications from disadvantaged schools. Professional, developmental, mentorship and leadership training can also be incorporated to strengthen and build mathematics capacity. In Sotho, it is said, *‘thupa e kotjwa e sale metsi’*, which translated means, if

you take young branch you can bend it, if you take an old one it will break. We need to look at examples, such as the following where these efforts are working. ‘...*in townships, we measure our potential by what others in our area have achieved*’, (Mcdonald Lebohang Nheke, student at the Didata Saturday School, 2001). With this philosophy in mind and by offering tuition classes on Saturdays, companies, like Didata, can start the recruitment of talented mathematics learners for mathematics and mathematics related training post matriculation. Of these programmes, Frank Chikane (2001) makes the criticism that, the millions of rands that corporate spenders are pumping into education is not making the expected impact. Government and funders need to get together regularly to talk about policy projects and priorities. An imbizo – an interactive form of governance –where planning is done consultatively and where the priorities of the government and industry can be declared. Clearly the efforts so far have lacked adequate consultation. According to the Corporate Social Investment Handbook (2001): there is the recognition of mathematics, science and technology as areas of particular importance. With that recognition, we need programmes to intervene in the traditional classroom, and change girl’s attitudes towards mathematics. Although these companies, appear to focus on areas in education which are also priorities of the department of education, their spending has to

- Be more equitably co-ordinated in terms of addressing race and gender imbalances
- Based on understanding of how mathematics fits in the education system
- Be receptive to recent research and new policies and practice to help with decisions based in particular on equity and redress
- Provide an interface between the business and education sectors so that each understands the realities facing each other
- To redress imbalances in employment and training to make the African female a priority

This will not only develop females in mathematics, but ensure that their participation in mathematics. The affirmative action quotas that companies have to meet in terms of female representivity and race will ensure that African females are given opportunities.

7.4 Implications of the Study

7.4.1 for female learners

The attraction and retention of female learners that are good in mathematics to mathematics fields has to be addressed on multiple counts. First, they will have to be incentivised to enter teacher training programmes so that a sustainable corp of qualified teachers is available. There is a complete lack of recruitment drives for potential teachers where 'if you can't.... then teach' and the closing of many teacher training institutions, leaves the general public sceptical on the value that our society places on teaching as a profession.

Second, we can adapt programmes that were successful in increasing the participation of female learners. For mathematics equity to improve, this study points to universities networking with schools and becoming more involved because university is where the largest attrition of females occurs. To borrow from the University of Minnesota's Talented Youth Mathematics Programme, 2 hours a week after school got talented learners credits to enter the university's mathematics programmes (Secada, 1995). These credits could also be transferred to other institutions. This would address equity and excellence. In addition provide female learners with information on the nature of mathematics so that students understand career opportunities in mathematics and related areas. It would be an environment that would be challenging and success-oriented and providing for learners a view of the world of mathematics outside of school.

Third, female learners need to be taught positive working habits in mathematics and credited far more for the homework that they complete, rather than the reliance on assessment being formal tests. The curriculum needs to be exposed to females and their participation in it needs to be negotiated with and not around them. The benefits of studying mathematics must be made explicit. We need to affirm the role of hard work and create a culture that endorses this work ethic. Numerous studies on the learning of mathematics point to females learning best through self-instruction. To break from the normal pattern they are to be taught that the teacher never teaches the entire class a particular concept, but rather when they require assistance they request

it. This encourages a more independent learner and a sense of responsibility. Each in her individual's style of learning and understanding can then approach the mathematics. Some girls in the sample of this study indicated that they best learned their theory by making posters and placing these at strategic positions in their homes.

Fourth, females must be recognised as individuals and not as mathematics classes. They need to perceive the teacher as a facilitator of the curriculum and not the source of all knowledge. They should ensure that they are motivated and alert in mathematics to challenge and contribute to discussions. We must stop expecting less of our female learners and they will offer us more. Expect excellence. They need to take responsibility for understanding their mathematics and not make it the sole responsibility of their teacher.

Fifth, need community linkage and support for any advanced program to succeed. Tobias (1990) noted that the type of exposure to courses makes a big difference to choices as majors. Girls seemed more affected by this. All programmes need to start with high standards and expect girls to succeed in them. Personally, from my own experience the learning of calculus should start earlier and not only in grade 12. This would assist many learners at university and show relevance to the mathematics that they learn.

Sixth, affirmative action should place gender as a priority where training and employment are awarded to competent girls first. Bursaries need to be offered to females that choose mathematics and science. Unpack political, social, cultural baggage by exposing learners to these debates and how these parameters are reflected in and perpetuated through the classroom and in particular, the learning of mathematics.

7.4.2 For teachers of mathematics

Schools are powerful in teaching learners their part in the social order. Socialisation patterns of formal schooling seem to affirm white males who then exit the system as the most confident and into tertiary study particularly in mathematics and the

sciences, which prepares them for the higher paying and status jobs of society. How and where does the disengagement of females occur?

The participation rates of females nationally at matric, at Ridgepark College and at Universities are generally, in decline. Teachers can exert influence at the start of this downward spiral. A start would be to control the discourse in classrooms. Teachers send out strong signals about knowledge and the most valued ways of teaching, knowing and learning. This has a significant impact on how females will construct mathematical knowledge. Teachers need to ensure that they don't send out messages that regard females as secondary participants in mathematics. We have to question why the overall participation and performance rates in mathematics females are lower than for males. Clearly our competitive classrooms, an emphasis on right answers, the teacher responsible for the learning and understanding, rejection of alternative ways of reasoning or working, the subtle favouring of genders or races has influence on female trends.

Cultural practices further debilitate females where certain groups do not question or challenge. These girls have to learn to have a public presence that is the core for success in mathematics when we compare the confidence of white males by merely examining their career trajectories. Females must be brought into the mathematics discourse in the classroom, even if the teacher is only able to expose the differential treatment patterns.

Teachers are seldom critical of the curriculum and with good reason; their voices are never heard by the education authorities. This impacts directly on the way that learning is controlled. Mathematics is portrayed as abstract, removed from the realm of real experience. Females learn mathematics with a strong sense of disconnection. They adapt their learning to cope with this exclusion. They opt out physically from mathematics by not choosing it or less obviously, they exclude themselves from the classroom discourse. The opportunities for their validation in the subject becoming scarcer. A supportive environment where females see connection and the building of ideas would favour female learning compared to the present. Ironically at the heart of mathematical discovery, is the idea of the 'connectedness' of knowledge. Intuition and creativity are the impetus. Yet, most mathematics is devoid of these connections

.The traditional mode of mathematics is abstract, removed from the human context, and exclusive. Borasi (1991) showed the image of mathematics as cold, hard and impersonal, is at the top of reasons for women not liking mathematics and their reason for abandoning it. Such were learner responses in the sample. Most of the learners in the sample drew representations of mathematicians: the majority showed white males, the remainder showed unmoving rigid structures such as Oak trees. I found my mathematics teacher to be cold and distant (a (4)) and longed for affirmation. One gets the sense from the autobiographies that these girls do too (see e (4)). Many wrote of the sole, alienated male engaged in the mathematical processes in very clinical exclusion. These impressions reinforce that females cannot be mathematical, not because that can't but because they choose not to.

Research on the learning of mathematics suggests that, no matter what the cultural background, all students learn mathematics in similar ways. Mathematics ideas need to made part of the female's internal network of ideas. Understanding is reached when females are able to make connections and links with the mathematics to what they already have made sense of. Teachers need to link the intuitive, informal knowledge that learners already have, to what is expected of them to learn. Females need to feel a sense of control over their environment and learning and the responsibility for learning has to be placed with them. Teachers need to offer more support for learners as they make these decisions.

Many decisions governing the ability of mathematics learners are made on the basis of their socio-economic, racial or gendered circumstance. Often prior knowledge that is expected of learners for a lesson has not been bridged for females and learners of colour. Girls need to feel that their teacher is accompanying them on the instructional journey, that they receive immediate or frequent comment on their progress. We find that if teachers accept that certain groups of learners have lower academic potential then they demand compliance around issues of discipline and deportment (Secada, 1995). These aspects have very strong emphasis in all-girls schools.

We need to help females to develop ways of learning mathematics that allows them to perform at higher, more sophisticated levels in mathematics. They need to function at

these levels and not merely conform to fit in. Teachers need to treat learners as though they are capable of learning mathematics and provide equity of access to all cultures, races and gender in the mathematics classroom. Aspects of teacher's behaviour convey messages of the expectations for genders, races and class. Teachers must make their knowledge a resource to all learners and mathematics teachers in particular must focus on the development of the child's own expertise. Expose the arbitrary power relations in the classroom and attempt not to reinforce them. Studies by Sadker & Sadker (1994) showed that white males receive the most positive attention in the class; they are pushed to think, to expand ideas, to defend their positions. They are being prepared to succeed in the world by discourse. This is preparation for adulthood. African learners by contrast, receive more negative feedback for behaviour, and more positive-negative feedback (comments that begin as positive, but include a negative modifier), thus sending a mixed message. Females receive less praise and less negative behaviour feedback, less neutral procedure feedback and less non-academic feedback. They therefore have a different educational experience. Learners not critical of this dynamic are taught, subconsciously, that this is normal. Gender stereotypes are ingrained and invisible. Teachers, therefore have to assess their engagement and the quality of their engagement of female learners. How do we treat learners that may not be performing well? What are the levels of questions that we reserve for our female learners? How do we distribute the time between the learners in our classes with respect to their mathematical abilities, race, gender, and socio-economic level?

Females seldom challenge. They mirror the behaviours of those that they like or those that can reward them. For students it is the teacher that has this power. The mathematics discourse plays this sex role socialisation. Damarin (1991) points out that for many centuries mathematics was the arena for men, and the language reflects that with its references to aggressiveness- mastery, power, hierarchies of objectives. The abstraction and the language of aggression very often silences females. There is a need for connection in order for females to feel part of this connection: 'women learn abstraction best, if statements of rules are preceded by quiet observation, by listening to each other and by personal experiences, that women can relate to the abstractions (Damarin, 1991). Girls need connection, collaboration, and co-operation.

There is also the need to evolve the language of mathematics to a level that is user-female -friendly.

We need formal programmes that target these educators for in- service training. Resources have to be directed to support the development of educators in mathematics as well as to attract educators to the field. Incentivise, particularly female students that choose mathematics teaching, through bursaries. Those that qualify should receive mathematics-teaching bonuses and improved higher salary scales.

Need to provide a positive social and family context for learning, where parents encouraged to attend activities and assist their children carry out commitment to mathematics learning. It must be joint effort to emphasise mathematics as an exciting challenge, to provide for the psychological and emotional needs of learners, improving the esteem and their sense of accomplishment. Families can provide a home environment that is conducive to success in participation. Where they may not be able to help with theory they can provide a study environment that values and encourages participation. Workshop parents on learning skills and gender issues. They are the most powerful lobby when it comes to negotiating with politicians and funding organizations.

Mathematics camps are known to work in many countries and can be organised during the July vacation. Focus on females that are at the point of choice of decision. Activities must be female friendly, hands-on, fun, at times informal, introducing role models (graduate students or people working in mathematics or science). They can only assist with the commitment to mathematics and changing the perceptions of people.

This study makes the following specific recommendations:

- 1) Teachers need to feel empowered to make input about the curriculum. Because the education department infrequently solicits opinion about curriculum change, is not good enough reason to feel silenced.
- 2) Upgrade methodology and instruction. Through professional teacher organizations or through the existing mathematics team at the school.
- 3) The quality of mathematics and the levels at which it is taught especially to disadvantaged females has to be raised. Teachers make the assumption

that females, Black females cannot cope. This is prejudicial and harmful to these learners. It has always been a motto of my teaching that 'the more you expect of learners, the more you will receive'

- 4) Access to mathematics must be made easier at high school
- 5) Parents need to be more formally involved and offer support to mathematics departments, particularly at schools. They could be role models or provide these from their working environments. They organise and assist in programmes that teachers construct to help learners, lobby with education authorities on issues regarding policy and the acquiring of financial aid to run mathematics-advanced programmes.
- 6) Teachers can provide opportunities for learners to experience the working world of mathematics through integrated work experience programmes. They will be able to see the value that society attributes to occupations that have mathematical bases, they will see the types of people that occupy these positions and they will see the connection between mathematics and the world of work. The compilation of a directory of females in mathematics and science is now a very special project that has evolved from this study.

7.4.3 For future research

Much research, on gender reflects a medical metaphor, that it is diagnostic rather than prescriptive. It begins with an observation that a part of the system is unhealthy. Researchers then explore the symptoms and attempt to diagnose the systemic illness. Often the perspective from the researcher is one of detachment from the problem. Observation, diagnosis, prognosis, and prescription. The patient is then given the bitter pill to swallow assured that it would be curative and restorative rather than debilitating or destructive.

What research needs to do is move from the problem –oriented description to the analysis of alternative explanations for the causes, to recommendations that are tightly linked to description and analysis. We need research not to appear as the standard formula, idiosyncratic and academic endeavour that it does. We need to acknowledge that no research is neutral because it involves selecting information and assigning

priorities. Where these are made explicit and not disguised in a muzzy academic haze, the receivers of the research can determine the utility of the information and its agenda in the recommendations. In addition, recipients of the research are regarded as consumers of the research and not owners. They operate as the patients and not the doctors. Interventions are insertions imposed from the outside and not initiatives form within.

This study sought to explain the lower participation and performance of females in mathematics, in and out of school. It examined parental attitudes, expectations for future income, female's responsibilities, the absence of role models, implicit and explicit discouragement against the study of mathematics further and parent's level of study. Its impetus arose from the simple recognition that in the highest levels of mathematics in South Africa, females are absent.

There is further need for the study of how single sex schools affect educational outcomes.

We need to know how indigenous knowledge fits in and complements contemporary knowledge systems. We need to understand why certain females are able to succeed in mathematics despite disadvantaged backgrounds.

We need to understand how gender impacts on curriculum change.

Appendix 1



PROVINCE OF KWAZULU-NATAL
ISIFUNDAZWE SAKWAZULU-NATAL
PROVINSIE KWAZULU-NATAL



DEPARTMENT OF EDUCATION AND CULTURE
UMNYANGO WEMFUNDO NAMASIKO
DEPARTEMENT VAN ONDERWYS EN KULTUUR

NORTH DURBAN REGION		ISIFUNDAZWE SENYAKATHO NETHEKU		NOORD DURBAN STREEK	
Address:	Truro House	Private Bag:	Private Bag X54323	Telephone:	31) 360-6911
Ikheli:	17 Victoria Embankment	Isikhwama Seposi:	Durban	Ucingo:	
Adres:	Esplanade	Privaatsak:	4000	Telefoon:	
				Fax:	(031) 337-4261
Enquiries:	Dr D W M Edley	Reference:	2/12/2/3	Date:	05 April 2000
Imibuzo:	360-6247	Inkomba:		Usuku:	
Navrae:		Verwysing:		Datum:	

The Directors: Provision and Administration
The Acting Director: Education Support Services
All Chief Superintendents of Education (Management and Academic)
All Superintendents of Education (Management and Academic)
The Principals of all Schools in the North Durban Region

Dear Colleagues,

NDR NOTICE No. 15 of 2000

REQUESTS FOR PERMISSION TO UNDERTAKE RESEARCH IN SCHOOLS IN THE NORTH DURBAN REGION

1. Kindly note that in order not to disturb the normal programme of teaching and learning in schools, no person or institution may conduct research in any school in the North Durban Region without the express permission of the Regional Chief Director, or his delegate.
2. All requests for permission to conduct research must be addressed to the Regional Chief Director, For Attention: Dr D W M Edley. Dr Edley will co-ordinate all research efforts and issue letters granting permission on behalf of the Regional Chief Director. No person should be admitted to any school or institution for the purpose of conducting research without such a letter of permission.
3. Your co-operation in ensuring that this measure is enforced will be appreciated.

Yours faithfully,

Dr G K NAIR
REGIONAL CHIEF DIRECTOR

Appendix 2

Your Ref: Ms.Regina Essack
Ridge Park College
Overport
Durban
4091
Tel: 082 74 55 73 8

02 April 2001

Dear MR & MRS I. HARRIS

Permission for your daughter to participate in a Masters Research Study

I am currently teaching your daughter mathematics at Grade 12 level. Concurrently, I am also involved in the completion of the second year of my Masters programme in Education. This year involves the completion of my research thesis towards the fulfilment of the degree.

My research is a gender study that focuses on aspects of Mathematics teaching and learning; the choices that female learners make; and the factors that influence these choices. One has only to examine the matriculation statistics at the end of every year, to notice the disparity in the levels of performance between boys and girls. This then filters the employment options open to our daughters. It has to be more than an idle curiosity that males dominate all decision-making positions, particularly in Mathematics and the Sciences. For me, the critical question is:

"What is it in our present curriculum that disadvantage the performance and choices that our daughters make."

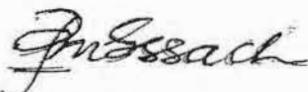
Your daughter will be involved in the compilation of a journal that will answer questions that I consider crucial to her learning and understanding of Mathematics. I am fully aware of the pressures of the matriculation year and would like to assure you that all attempts will be made to guarantee that she is not disadvantaged through her involvement in this study. I do believe that her involvement and exposure to research at this level, which will include the publication of selections of her work, will benefit not only your daughter, but also future generations of female mathematics learners.

Your daughter will also be required for interviews related to my thesis and for the sake of transparency I am committed to giving you, as her parents, full access to all her responses, be they written or verbal.

I am very excited about mathematics and enjoy teaching it. It is a privilege to be able to work with your daughter and my hope is to create a learning environment that will enable them to prosper.

I will be most grateful for your consent.

Yours truly,



Regina Essack

*Regina,
We agree to Gaylene being
involved with your research.
I also wish you well in
the completion of your studies.
Bill*

Appendix 3

Schedule of Guided Questions that formed part of the Autobiography

Part A

All About You – Your Life

Part B

Your Mathematical Life

1. Can you recall an experience in the mathematics classroom that stands out in your memory?
2. Why did you choose mathematics at Grade 10 level?
3. Do you consider yourself to be successful in Mathematics?
4. What reasons would you give for your success?
5. Would you recommend Mathematics to other girls? Why?
6. What about Mathematics do you like/enjoy?
7. What about Mathematics did you dislike ?
8. What about the Mathematics that you have experienced would you change?
9. What are your career choices for next year?
10. How is Mathematics related to your career choice ?
11. Where there any difficulties that you experienced in Mathematics because you were female?
12. What about Mathematics makes you continue to succeed / persist when so many girls opt out?
13. Are there any women in Mathematics or Mathematics related fields that have inspired you?
14. Who are they and how were they an inspiration to you?

Appendix 4

Schedule of Questions used in the Interview

In this unstructured interview schedule learners will be asked about their mathematical life histories

Questions Relating to Self:

1. Can you tell me about a critical incident in mathematics in primary school?
2. Recall a critical incident in mathematics in secondary school?
3. Who has been most influential in shaping your thinking regarding mathematics?
4. What are your thoughts regarding the subject?
5. How would you describe your mathematics experience thus far ?
6. Do you think that mathematics is useful to you at present ?
7. Do you think that it will be useful in your career?
8. How do you feel about being good in mathematics?
9. In situations outside of the classroom, do you use the mathematics that you've learned in the classroom?
10. How would you describe yourself in mathematics?

Relating to Career

1. Did you receive career guidance ?
2. If yes , where?
3. List fields that were recommended to you ?
4. What do you want to do after matric?
5. Has this changed since primary school?
6. What do you think about a women scientist /mathematician?
7. Who are your role models in mathematics ?
8. Would you choose mathematics as a career? Supply explanation.
9. What career would you definitely not choose?

Relating to Family Background

1. Can you tell me how many are in your family?
2. How have / do your siblings perform in mathematics?
3. What contributed most to your choosing mathematics in Grade 10?
4. How did it contribute?
5. Do your parent support the choices that you have made for post matric?
6. What occupations are your parents in ?
7. Have they studied maths and to what level?
8. What are your father's views of mathematics?
9. What are your mother's views of mathematics?
10. What support do your parents offer your study in mathematics?
11. What would your parents reaction be you decided to study mathematics further?

Additional Short Questions

1. Is mathematics about understanding or learning your work?
2. Is it presented to you as things that you have to remember or as things you have to work through and understand?

Rank the following in terms of important or not important and briefly explain

1. getting a lot of work done
2. working at a fast pace
3. understanding
4. remembering rules and methods
5. knowing how to use technology

Appendix 5

Omar Essack

From: Omar Essack
Sent: Monday, December 03, 2001 1:59 PM
To: 'mkahn@wn.apc.org'
Subject: Gender data

Dear Michael,

You kindly sent me data on powerpoint with statistics on registration and performance in Maths HG divided by gender for each province.

I need clarity on some of these figures. It seems as if Gauteng and Western Cape reflect a total entry of 812 and 78 students respectively, while the Northern Province shows 7780 and KZN 5772 entrants at Matric maths HG. Can this be right?

I tried telephoning your office line with no success. I shall avoid calling your cellphone unless absolutely necessary. Thanks in advance for your help.

Omar Essack
Managing Director
East Coast Radio
Durban
South Africa
27 82 55 94 951(All Hours)
27 31 2079411 (Fax)

Omar Essack

From: Michael Kahn [mkahn@wn.apc.org]
Sent: Saturday, December 08, 2001 2:55 PM
To: Omar Essack
Subject: Re: Gender data

Sorry at the delay.

Yes, the figures are 'right'. Remember these are students that take African languages.

We assume (correctly) that most Africans take an African language and most non-Africans do not.

The figures are probably good to 5%.

Even if WC is out by 100% it is still a scandal.

Appendix 6

1. UDW Degrees: All B.Sc Degrees involving mathematics
2. UND Degrees : All B.Sc., B.Comm. , B.A degrees and post graduate degrees involving mathematics
3. UNISA. All degrees involving mathematics and applied mathematics

Participation and Performance Statistics in University Mathematics- UDW, UND, UNISA

University of Durban Westville Participation and Performance Statistics For Mathematics Related Degrees										
Participation										
	Black		Coloured		Indian		White		Total	
Year	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1996	146	117	1	2	172	167	4	2	323	288
1997	132	135	2	2	150	131	2	1	286	269
1998	104	110	0	1	120	85	0	0	224	196
1999	82	57	1	1	71	77	0	0	154	135
2000	142	85	1	0	92	67	2	0	237	152
Performance										
1996	8	3	0	0	3	7	0	0	11	10
1997	2	2	0	0	9	6	0	0	11	8
1998	2	1	0	0	16	3	0	0	18	4
1999	1	1	0	0	8	3	0	0	9	4
2000	1	3	0	0	4	2	0	0	5	5

				Uisa						
	Participation Statistics - Mathematics Related Degrees									
	2001		2000		1999		1998		1997	
Province	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
EC	82	79	69	94	114	116	148	306	178	201
FS	99	28	105	28	108	26	131	184	128	39
GAU	2075	1055	2020	957	2033	905	2255	3436	2293	1017
KZN	649	314	716	290	756	403	1017	1578	877	558
MP	200	63	237	83	207	107	276	406	311	128
NW	201	81	183	88	189	89	252	416	220	156
NC	35	11	19	16	21	22	16	41	32	23
NP	272	143	324	111	336	132	487	715	661	257
WC	442	169	427	168	465	177	477	669	495	228

University of Natal										
Participation Statistics- Mathematics Related Degrees										
Year	Black		Coloured		Indian		White		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1997	186	80	2	1	103	39	58	37	349	157
1998	111	47	3	1	124	66	52	32	290	146
1999	68	25	3	0	93	41	30	37	254	103
2000	67	40	3	1	61	28	30	22	161	91

University of Natal										
Performance Statistics - Mathematics Related Degrees										
Year	Black		Coloured		Indian		White		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1997	20	11	0	0	15	0	14	11	49	22
1998	12	11	1	0	16	6	11	7	40	24
1999	5	1	0	0	15	6	5	9	25	16
2000	13	10	1	0	5	4	8	7	27	21

Females UDW & UND Combined										
	Black		1 + 2 + 3		1. Coloured		2. Indian		3. White	
year	Part.	Perf.	Part.	Perf.	Part.	Perf.	Part.	Perf.	Part.	Perf.
1997	215	13	211	17	3	0	170	6	38	11
1998	157	12	185	16	2	0	151	9	32	7
1999	82	2	156	18	1	0	118	9	37	9
2000	125	13	118	13	1	0	95	6	22	7
total	579	40	670	64	7	0	534	30	129	34
part/perf%	6.90%		9.60%		0%		5.60%		26%	

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