TOWARDS SUCCESSFUL MATHEMATICAL LITERACY LEARNING - A STUDY OF A PRESERVICE TEACHER EDUCATION MODULE

by

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ABSTRACT

The purpose of this study was to extend our knowledge about mathematical literacy learning with the focus on a foundational preservice teacher education module required for prospective teachers. The construct of mathematical proficiency provided a framework for understanding how successful learning depends on a multiplicity of competences, and in particular to highlight the pivotal role of a productive disposition towards mathematics in becoming mathematically literate.

The main questions that guided the study were as follows: What is the nature and strength of the productive disposition strand of mathematical proficiency evident in preservice teachers entering a Mathematical Literacy module and how does this productive disposition change over the course of the module? and What pedagogical practices and learning behaviours best enable preservice teachers to achieve mathematical literacy? The study was undertaken as two overlapping case studies, the first describing the preservice teachers at the onset of their studies in the Mathematical Literacy for Educators module, and in the second, a three part story-telling case study of the unfolding of the module over three years from 2003 to 2005.

The mathematics autobiographies of 254 preservice teachers and the data obtained from a premodule questionnaire and introductory class activities contributed to the first case study which was summarised in the form of three fictional letters. Written reflections, final module evaluations and the insights of my co-workers contributed to the second case study which documented the successes and struggles of the preservice teachers as the module unfolded each year. Complementary mixed methods techniques were used to analyse the multiple sources of data and to weave strong ropes of evidence to support the findings. Statistical analysis pointed to themes which were supported or tempered by qualitative evidence reported in the voices of the preservice teachers themselves.

The analysis revealed that many of the preservice teachers entering the Mathematical Literacy for Educators module had found their school experience of mathematics to be dispiriting and consequently had developed negative dispositions towards the subject. The change in this disposition depended on their success in the module and the empathy shown by the lecturer. Helpful pedagogical practices were found to be those that supported

language difficulties in learning mathematics, assisted in organising learning, remediated for poor schooling background in mathematics and took account of the diversity amongst the students.

I argue that many of the lessons learned and insights gained from teaching the Mathematical Literacy for Educators module are relevant to the expanding number of mathematics courses required as part of humanities programmes. In addition, they can inform practices at school level and in both in mathematics and mathematical literacy teacher education.

PREFACE

The work described in this thesis was carried out in the School of Science, Mathematics and Technology Education, University of KwaZulu-Natal, from *January 2003* to *February 2007* under the supervision of Prof Claudia Mitchell (Supervisor) and Prof Delia North (Co-supervisor).

Ethical clearance was granted for this project by the University of KwaZulu-Natal Research Office. The Ethics Clearance Approval number is HSS/06106A.

This study represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others, it is duly acknowledged in the text.

Sally Hobden
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I would like to express my thanks to the following people and institutions, and to acknowledge their contribution to this research project.

To the students in the 2003, 2004 and 2005 mathematical literacy classes who so willingly shared their mathematics stories with me, and who did so well to overcome their troubled mathematical past.

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Dedication

This thesis is dedicated to those who learn mathematics with difficulty.

ABBREVIATIONS AND ACRONYMS

ABET	Adult Basic Education and Training
ALM	Adults Learning Mathematics
B.Ed	Bachelor of Education
DP	Duly Performed Certificate
FET	Further Education and Training
GET	General Education and Training
ME	Mathematical English
MLE	Mathematical Literacy for Educators
NQF	National Qualifications Framework
OBE	Outcomes Based Education
OE	Ordinary English
PGCE	Postgraduate Certificate in Education
PISA	Programme for International Student Achievement
QPU	Quality Promotion Unit
RNCS	Revised National Curriculum Statement
SAQA	South African Qualifications Authority
SGB	Standards Generating Body
TIMSS	Third International; Maths and Science Study
UKZN	University of KwaZulu-Natal

Notes on the stylistic conventions used in the text

Pseudonyms have been used throughout the study to protect the privacy of the preservice teachers, and those who worked together with me in the teaching of the modules. The only true name mentioned is my own as it occurred in the speech of the participants.

Citation conventions

This study contains many direct quotations in the voices of the participants. These are, in all cases presented in italics within the text. If the source of the quotes is obvious from the context in which it is presented (for example in a discussion of response to the 2003 module evaluation) then only the name of the speaker is given.

In most cases the quotations are verbatim, but on occasion minor editing was undertaken to remove extraneous "you knows" and other "pause phrases" that added nothing to the meaning. The original grammar was retained.

Number conventions

A decimal point has been used in all statistics reported. The decimal comma, as used in South African schools, is used when illustrating student work.

CHAPTER 1

INTRODUCTION

This study was prompted by current and national moves towards mathematical literacy for all, and is conducted from my personal standpoint on social justice and equity, coupled with my interest in teaching and learning mathematics. It builds on the work of my Masters research in the area of preservice teachers' personal beliefs about mathematics teaching and learning, my work with constructivist theories of learning, lengthy experience of teaching "mathematics avoidant" preservice teachers, and an ongoing effort to support students who are dealing with a political legacy of poor basic mathematical education, language difficulties and unfamiliarity with academic institutions.

1.1 INTRODUCING THE SOUTH AFRICAN CONTEXT

It would be very difficult to understand the issues discussed in this study without some knowledge of the history of South Africa, in particular the history of the unequal provision of education. Access to education has traditionally been seen as a right for the rich and upper classes, and a privilege for the poor and lower classes, but the politically motivated entrenchment of this in South Africa between 1948 and 1994 exacerbated the situation. Mathematics education was publicly and notoriously politicised by the words of the then Minister of Native Affairs (and later Prime Minister) delivered after the reading of a parliamentary bill on Bantu Education: "When I have control over native education I will reform it so that the Natives will be taught from childhood to realise that equality with Europeans is not for them…People who believe in equality are not desirable teachers for natives…What is the use of teaching the Bantu mathematics when he cannot use it in practice? The idea is quite absurd. (*House of Assembly Debates* Vol.78, August - September 1953: 3585)

It is no wonder that the intervening 41 years of unequal opportunity between that speech and the advent of a new democratic government, have resulted in a "socio-cultural and political context deeply scarred by Apartheid education" (Adler, cited by Parker, 2004, p. 122). Mathematics learning is particularly affected by dysfunctional schooling since its success depends so greatly on building new concepts on the foundations of previous learning.

As part of a national policy of transformation, "the curriculum, including the mathematics curriculum of post-apartheid South Africa declares a clear intention directly and explicitly derived from its constitutional mandate to address issues of discrimination and social justice" (Vithal & Volmink, 2005, p. 15). Even when there is political will to provide mathematics education for all, and to use mathematics as a means of social transformation, the situation remains bleak for the majority of the African population, especially in rural areas where poverty, unemployment and the AIDS epidemic are rife. As Vithal and Volmink remind us "the competing demands of creating mathematics curricula that satisfy society's needs for mathematicians, statisticians etc., while also assuring mathematical competence for the rest of civil society…produce stark tensions in a society such as South Africa, where large inequalities exist in access to mathematical education, provision of resources and opportunities to learn" (2005, p. 17). Clearly, issues of social justice pervade all work in education in South Africa.

1.2 INTRODUCING MYSELF AS THE RESEARCHER

I am a white woman born in the 1950s in South Africa, and therefore grew up in purposefully segregated society with a privilege that was for me implicit and seldom discussed. I attended the local government school, walking to school each day. The classes in the primary school consisted of about 40 learners. My choices for tertiary education were constrained by the bursaries and scholarships available. Although not overt, I always felt that gender discrimination prevented me getting any of the various industry sponsored chemistry bursaries that I applied for. In the end, I took a teaching loan from the Natal Education Department (which was duly repaid by four years of service at a school of their choice) and did a Bachelor of Science degree. Alongside my academic progress, my involvement with social justice groups within the church community led to my progress in understanding the injustices of society and my increasing unease with the status quo, and the role white youth were expected to play in protecting it through military service.

My initial teaching work brought me into contact with learners who struggled with mathematics and I began to see the magnitude of the obstacle it was to them. Over the next few years I did tutoring in Saturday schools for disadvantaged learners, catch-up lessons with learners who had taken refuge in the church building from the violence in the townships, and private lessons for advantaged learners who were struggling. Working with these different learners showed me that mathematics is a problem across all race groups and all socio-economic groups, but of course, the choices for remedies are much greater for those with resources. On returning to work after a ten year break to bring up three children, I was employed in a College of Education which was beginning to be open to all race groups. This teacher education work continues, and being at a tertiary level and involving often older students, the legacy of poor education in disadvantaged areas continues to manifest itself. Furthermore, these disadvantaged students are expected to conform to expectations put in place by the university which assumes adequate secondary education and familiarity with the tools of academia. This gives rise to personal tension as, for example, I know that some students take a while to adjust to the university life and yet they are given no chance to redeem the poor marks they might score in the first few tasks of the year and so fail despite clear improvements made during the semester.

In essence, the research for this study arises out of my commitment to justice, fairness and equity in mathematics education. While hoping to avoid what Griffiths (1998) terms a "sentimental commitment to the underdog" (p. 3), I need to make explicit my commitment to promote the principles of social justice and to endeavour to give voice to those who are disempowered for whatever reason. While I acknowledge that the power relationships in the research are unequal, I have positioned myself both as a researcher for the participants in my study and as their advocate. I hope that this position becomes evident to the reader, as the research project is described.

1.3 PERSONAL MOTIVATION FOR THE STUDY

Mathematics is a high status subject in the South African school system and in the eyes of the community. Ability in mathematics is often viewed as an indicator of general intelligence and as a consequence is used as a gatekeeper to various professions. Because mathematical success is so closely tied to language and socio - economic class (Howie & Plomp, 2002), this is a politically-loaded justice and equity issue. I recall a practising teacher in a Masters seminar wondering how it could be that a person is denied entry into Medical School because "I am not knowing how to prove the proportional intercept theorem." Good performance in mathematics relies on exposure to all parts of the curriculum and it is well known that in many schools the geometry sections are not taught, so that learners might do well on all the work they have been exposed to but on average obtain low marks. Many are victims of a South African schooling system that does not deliver evenly to all socio-economic classes (Reddy, 2006b).

Students entering the Faculty of Education undergraduate programmes require a matriculation exemption which is achievable without passing mathematics at Grade 12 level. Once admitted they are deemed to be in deficit if they do not have a pass in Grade 12 mathematics and are required to do a foundational module in mathematics. It is not easy to overcome a poor arithmetic background which leaves a person trying to make sense of more advanced mathematics amid a confusion with basic skills. While not disputing the value of being mathematically literate, I am concerned that the requirement of this literacy is yet another obstacle in the path of the most disadvantaged sectors of the community. Every effort has to be made to redress the legacy of poor primary school education and to rebuild confidence that has been eroded by a history of mathematics failure and derision.

I was pleased then, to take up the task of teaching the Mathematical Literacy for Educators (MLE) module which stands as a gatekeeper to the Bachelor of Education degree even for students who do not intend to teach any mathematics at all. This provided me with an opportunity to make a difference. In 2003 when the initial MLE module ran, I was also involved in teaching a module on Academic Learning in English, and a module of campus-based practice teaching with first year students. I thus had close and regular contact with about 90 first year students. It became clear to me that these students were tossed into the university system with little or no support. Many were not first language English speakers, some were older students, some from other countries, some from rural areas or disadvantaged schools, and others were from privileged backgrounds having attended private schools and having a culture of independent learning. I could not help noticing the injustice of the most confused students writing out their academic essays by hand without the advantage of spelling or grammar checks, and starting from scratch every time the draft was created, because they had been too late to put their names on a list for computer literacy in the first semester. Advantaged students who knew the system got themselves into the first semester cohort and were promptly excused the lectures due their existing computer skills. Against this background, many were required to do a mathematics module and this provided an opportunity for me to help and advocate for disadvantaged students. Within the university system, any position of advocacy is strengthened by careful research and extensive supportive data, and so the idea of this research project was born. Cochran-Smith and Lytle (cited in Breen, 2003) "describe ways in which the teacher-research movement has the potential to act as a transformative influence for university cultures as it collides with the long-standing tradition of universities to privilege research while holding teaching and service in relatively low regard" (p. 539). In my view, teacher research is a way of reconciling personal goals of excellent teaching and induction into the academic community, and the institutional goal of research output.

I have always been interested in helping people make sense of mathematics. I am particularly interested in working with those who do not have easy access to mathematical literacy due to barriers of class, gender, race, language and culture, learning difficulties, traumatic past experience with mathematics or insufficient foundational skills. I know that the students with mathematical flair have little need of teaching, and their ability and self motivation enable them to triumph over even the worst teaching. Those who find it difficult to learn mathematics need good teaching and very importantly encouragement and kind words to regenerate confidence and motivation. The MLE module was, and remains for me, an opportunity to help students overcome negative experiences of mathematics and enter the teaching profession with a more positive attitude and improved skills. Consequently, in line with the views of Griffiths (1998), this research is both motivated by social justice concerns, and by its advocacy stance, a desire to promote social justice.

The high status given to mathematics is a human attribution and I do not believe that mathematical knowledge is inherently superior to other knowledge domains. That said, knowledge of mathematics is empowering on a practical level in dealing with daily life, and on a personal self worth level. My belief that mathematics is constructed by learners leads to the idea that successful mathematics teaching and learning will depend on knowing the affective and cognitive characteristics learners bring to mathematics classrooms. Careful research is a means to such knowledge.

1.4 MATHEMATICAL LITERACY IN THE SOUTH AFRICAN CONTEXT

This study is set in the context of a changing South African schooling curriculum which has involved the introduction of a compulsory school Mathematical Literacy course for those learners not electing to study formal mathematics to Grade 12 level, and a compulsory university Mathematical Literacy module for prospective teachers who have not passed mathematics at Grade 12 level.

Internationally attention is being focussed on "real world" contextualised mathematics as opposed to the more abstract formal mathematical structures and rigor of professional mathematicians. This distinction has resulted in the two different subjects in the South African senior school curriculum, namely Mathematics (formal academic mathematics in preparation for tertiary study) and Mathematical Literacy (contextualised mathematics for personal use). Advocacy of mathematical literacy is based firstly on the obvious practical value of being able to deal with quantitative situations in personal and work situations. Schield (2002) notes that "anybody lacking this type of literacy is functionally illiterate as a productive worker, an informed consumer or a responsible citizen" (p. 41). This suggests a second motivation for a mathematical literacy programme, i.e. to develop the quantitative literacy required for responsible citizenship in a democracy. Steen (2000) considers this contribution of mathematical literacy to be its most profound value to society since "virtually every major public issue – from health care to social security, from international economics to welfare reform - depends on data, projections, inferences, and the kind of systemic thinking that is at the heart of quantitative literacy" (p. 35).

Without a specific mathematical literacy course, it will fall to individual students to apply the tools of formal school mathematics to situations arising in their daily lives, and to use these tools to make informed and responsible judgements regarding social and political issues. Unfortunately, in South Africa we have a situation where the pass rate of matriculation students on the Higher Grade (university track) mathematics examination is abysmal. Students who perform badly can hardly be expected to extract from the mathematics curriculum the content that they require to make sense of a twenty first century "world awash with numbers" (Steen, 2001, p. 1). While the case for mathematical literacy has convinced the curriculum developers in the South African National Government to include it as a compulsory course, concerns have been raised. The introduction of a compulsory course in mathematical literacy at schooling level has been contested on ideological grounds of perpetuating the inequities of the apartheid system, the inflated importance given to numeracy and practical concerns that there are inadequate resources for successful implementation, especially in disadvantaged schools. The same concerns apply to the implementation of compulsory mathematical literacy modules at tertiary institutions. Nevertheless, the international impetus of mathematics for all has prevailed, and at both school and tertiary level, mathematical literacy has become a requirement causing anxiety for many learners who would prefer not to engage with any form of mathematics.

The introduction, at schooling level, of a compulsory three year Mathematical Literacy course for those learners not electing to take the formal Mathematics course, removes the opportunity to cease the study of Mathematics at Grade 9 level. In my experience this was a favoured option for many learners who were mathematics anxious, mathematics avoidant and/or unsuccessful in school mathematics. Such students will form a significant group within the school Mathematical Literacy cohort since, at least initially, we can expect that the pattern of able students electing formal Mathematics for reasons of access to high status university courses will continue. Similarly, the university students who are required to do the mathematical literacy modules are those who had elected to terminate their study at Grade 9 level, or had unsuccessfully attempted the Grade 12 examination. These students, who are now adults, are unlikely to be excited at the prospect of taking up the study of mathematics again, making the role of affective factors in mathematical literacy classrooms significant.

1.5 SUCCESSFUL LEARNING OF MATHEMATICAL LITERACY

Successful learning is described using the construct of mathematical proficiency, as outlined in the seminal report, Adding it Up: Helping Children Learn Mathematics (Kilpatrick, Swafford, & Findell, 2001). Mathematical proficiency, originally conceived of as the desired outcome of school mathematics, and adopted in this study as the desired outcome of a mathematical literacy module, is conceptualised as consisting of five interwoven strands; conceptual understanding, procedural fluency, adaptive reasoning, strategic competence and productive disposition. All but the latter are concerned with mathematical knowledge and skills, and do not form the focus of this study although they clearly provide the backdrop. The productive disposition strand encompasses attitudes towards mathematics and self belief in the ability to succeed.

1.6 ROLE OF AFFECTIVE FACTORS IN MATHEMATICS LEARNING

We can expect affective factors to play a significant role in the learning of Mathematical Literacy ideas, especially in cases where patterns of repeated failure and learned helplessness have been reinforced over many years of schooling. I was guided by the views of Clark (1995), Manouchehri (1997), Thompson (1984) and Francis (1997) that the knowledge and attitudes that learners bring to the mathematics classroom and the knowledge and attitudes of the teachers they find in those classrooms together exert a powerful influence on the teaching style and the quality of mathematical learning that occurs. McLeod and Ortega (1993) further suggest that improving attitudes and disposition can have a beneficial effect on learning. It follows then that it is important to assess the range and strength of these affective factors, leading to the first research question:

Research Question One

What is the nature and strength of the productive disposition strand of mathematical proficiency evident in preservice teachers entering a Mathematical Literacy module?

Teaching Mathematical Literacy is a new experience for most South African teachers, at both school and university levels. Research is required to indicate best practice for teaching mathematical literacy, and whether this best practice is any different from formal mathematics teaching. The challenge is to devise strategies to overcome the legacy of an unsuccessful mathematics history and to develop a programme of advocacy to promote a disposition to learn "useful" mathematics. The need to evaluate the success of such strategies prompted the second research question:

Research Question Two

How is the productive disposition strand of mathematical proficiency of preservice teachers changed after completion of the Mathematical Literacy module?

The research was planned to span three successive cohorts of preservice teachers with the intention to reflect and improve practice in each cycle. It was important to look for success and to investigate to see how it can be promoted in all the learners. The identification of the factors that enable some of the preservice teachers to succeed where others fail can provide pointers to both good teaching and good learning practices. This concern led to my third research question:

Research Question Three

What pedagogical practices and learning behaviours best enable preservice teachers to develop Mathematical Literacy?

This work with these preservice teachers doing a mathematical literacy course in some ways foreshadowed teaching mathematical literacy to school going learners which began three years later in 2006. In addition to the improvement of the personal mathematical literacy of preservice teachers (the primary focus of this study), as a mathematics teacher educator, I am interested in the teaching and learning of school mathematics, and the development of preservice and in-service courses for prospective mathematical literacy teachers. I feel that this recent and relevant research could inform practice in schools by giving direction to both the style and content of the mathematical literacy courses at schools, and practice in university education faculties by informing the design of preservice and inservice mathematical literacy teacher education courses. A further application of the findings of this study lies in the foundational programmes required in the humanities, commerce and law, for mathematically underprepared tertiary students.

1.7 LOCATING THE RESEARCH WITHIN A PARTICULAR PARADIGM

Philosophically, this research is framed by principles of social justice. In the introductory chapter of her book, Griffiths (1998) outlines her view of the field of educational research for social justice in these words:"(It is) about using research for working towards justice, fairness and equity in education. It is about starting the process of educational research with a set of values that guide decisions about what is researched, and how and why. In other words, it is about taking sides and getting change in education through educational research" (p. 3). In a small way, working in my own institution, I hope to make a difference. Making public the stories of struggles with mathematics in a variety of contexts, and in some cases, against a background of dysfunctional educational environments raises the issue of access and redress.

Methodologically, this research is located within a pragmatic paradigm. Krauss (2005) describes two alternative paradigms that represent different epistemological viewpoints: (a) the positivist paradigm, in which the object of study is independent of the researcher and knowledge is discovered and verified by direct observation and measurement of phenomena, and (b) the constructivist or naturalist paradigm in which knowledge, understood to be context and time dependent, is established through the meaning attached to the phenomena studied by the interaction of the researchers and researched. Researchers in the former paradigm tend to be comfortable with the statistical analysis of quantitative studies, while qualitative approaches seem more suited to the latter paradigm. The pragmatic paradigm falls in the middle ground, and researchers operating in this paradigm typically utilise a mixed method approach (Johnson & Onwuegbuzie, 2004).

1.8 OVERVIEW OF RESEARCH DESIGN

This study was essentially a case study of a module Mathematical Literacy for Educators, bounded in time by the period 2003 (the initial year) to 2005; bounded in place by its location at the Edgewood Campus of University of KwaZulu-Natal; bounded in the community of researching and researched formed by the principal researcher, the tutors and teaching assistants employed each year, and three successive cohorts of preservice teachers. This case instantiates the foundational mathematics modules required in many South African university humanities degree programmes, for students who have not been successful in school level mathematics.

This study employed mixed methods in line with the pragmatic paradigm in which I have chosen to operate. Several styles of mixed methods are used, since, as Griffiths

(1998) reminds us, a "political strategy for educational research for social justice is not to be found in any one methodology or in any overarching grand plan", but rather each researcher should make use of the options and opportunities available to them within their own context. "The strategy is to do what you can, and to keep your wits about you, and your ears open, and still be able to live with yourself" (p. 147). Some of the fixed response data was quantitatively analysed, some issues were analysed qualitatively, and others by a combination of both. Mathematical proficiency as a construct is used as a framework to analyse the success of mathematical learning. The productive disposition strand of mathematical proficiency is informed by personal autobiographical accounts of mathematical history analysed according to a framework constructed from the literature, iterative coding of the data, and constructs emerging from factor analysis of questionnaires. Included in this are theories of self-efficacy which are useful aids in understanding the role of motivation in mathematics learning and engagement with the course work. Social constructivism as a learning theory is included in the theoretical framework because it is a way of understanding the success of independent study groups as an enabling factor in the development of mathematical literacy. All these theories work together to provide a framework for understanding the data and answering the research questions.

1.9 OVERVIEW OF THE THESIS

This introductory chapter in which both the motivation for the study and the research questions were presented, is followed by two chapters which review the literature and provide the context and theoretical framework for this study. Chapter Two outlines the field of mathematical literacy and how it is understood, contextualised and implemented internationally, nationally and institutionally. Against this backdrop, the university module Mathematical Literacy for Educators is explained and described, followed by a global picture of the preservice teachers involved in this module. The rationale for situating this study in the field of adult mathematical learning is also provided in this chapter. Chapter Three continues to provide background with a discussion of the literature relating to successful mathematics learning and both barriers and enablers to this learning. The literature related to mathematical autobiographies, both as phenomenon and research instrument, is also reviewed here. Moving into the actual research project, Chapter Four outlines the research design and provides detail of the construction, implementation and analysis of the nine research instruments used to inform the research questions. The first research question, relating to the initial productive disposition of the preservice teachers entering the MLE module, is addressed in Chapter Five by a combination of quantitative and qualitative methods which support each other and contribute to the strength of the evidence. The findings are summarised in the form of three fictional letters. Chapter Six is a rich description of the three cycles of the MLE module, and includes the data analysis of the various research instruments as they occurred. This provides the evidence to support the assertions relating to the final productive disposition of the preservice teachers, their achievements mathematically and the pedagogical practices and learning behaviours that best enabled their learning of mathematical literacy. The key themes emerging from this study are related to the literature to situate this study in the relevant fields. Finally, the dissertation concludes with Chapter Seven in which the implications of this study are presented in the form of recommendations both for teaching mathematical literacy modules at tertiary level, and for teacher educators and teachers at school level.

CHAPTER 2

HISTORY, POLICY AND CONTEXT OF MATHEMATICAL LITERACY

In this chapter I will begin by describing the upsurge of international interest in, and importance accorded to mathematical literacy as a compulsory component of secondary and higher education curricula for students considered to be lacking in mathematical literacy. This historical and international overview will be followed by a discussion of how the interest in mathematical literacy is interpreted in South African government policy in both the Further Education and Training (FET) Band and Higher Education, specifically with reference to teacher education. The University of KwaZulu-Natal (UKZN) response will then be described followed by a rich description of the module that is the focus of this study, and my rationale for locating the teaching of this module in the domain of adults learning mathematics. Finally, the preservice teachers who lie at the heart of this study which is both about them and for them, will be described. The nested nature of the chapter structure is illustrated in Figure 2.1.

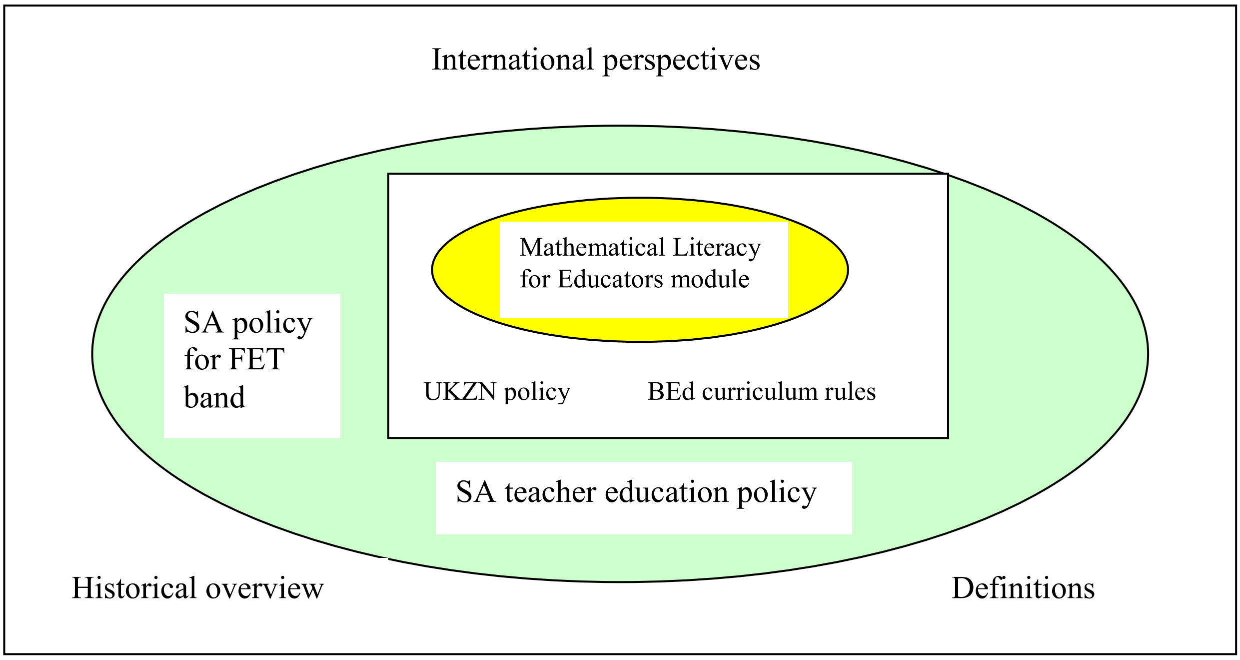


Figure 2.1 Illustration of the situation of the Mathematical Literacy for Educators module in international, national and institutional contexts.

The introduction of Mathematical Literacy as a school subject has been anticipated for several years, and was finally implemented in 2006. It forms part of the national policy for the FET band. The introduction of school level mathematical literacy has created public awareness and interest in the idea of mathematical literacy. Although a relatively new term and an explicitly stated idea in South Africa, the concept of mathematical literacy has its roots in history as will be discussed below.

2.1 INTERNATIONAL AND HISTORICAL PERSPECTIVES AND DEFINITIONS

In this section, the historical roots of "useful mathematics" are discussed, leading to a presentation of some of the definitions that emerged to describe mathematical literacy and then to a discussion of the arguments advanced in favour of increased attention to mathematical literacy. Finally, the important distinction between mathematical literacy as a competence and habit of mind, and as a subject to study is drawn.

2.1.1 Historical roots of mathematical literacy

It is not difficult to appreciate that historically the work of pure mathematicians in the domains of advanced calculus and geometry for example, and the day to day calculating of merchants and clerks were parallel streams of mathematical endeavour with different purposes and little in common. Madison (2004) cites Hardy's 1940 work "A Mathematicians Apology", as an example of the long standing "disparity that has existed for centuries, one that persists in twenty-first century America as a division between the rigorous mathematics that real mathematicians study, appreciate and extend and the contextualised mathematics of everyday life" (p. 9). This disparity was reflected in the use of the term "real mathematics" as opposed to the rather pejorative term "trivial mathematics" (Hardy, 1940) or "sophisticated mathematics" as opposed to "commercial arithmetic" (Cohen, 1982). The sentiment was clearly that "the bourgeois lads would find mathematics too difficult" (Madison, 2004, p. 9) and that simplified arithmetic was more appropriate for all but the upper classes. In America (and the largely immigrant population makes it likely that such practices were common in Europe at the time), historically arithmetic was taught very formally with each student creating their own copybook of rules and examples which became their reference book. These books were found to "eschew explanation, give minimal examples, invoke no repeat drills, and treat each type of problem as an universe unto itself, with nary a hint of logical connections between, say, subtraction and division, addition and multiplication, or fractions and decimals" (Cohen, 2003, p. 10). While these books were no doubt useful for merchants who used particular rules and ready reckoners on a daily basis, Cohen (2003) rightly observes that this "did little to enhance the generalised facility with numbers we now call quantitative literacy" (p. 11). The preface to an old book owned by my father as a young technician (Castle, 1943), originally published in 1900 and in its twentieth reprint by 1943, captures the practical (as opposed to theoretical) nature of the mathematics suggested for young workmen: "To perform his work intelligently, an artisan must have a knowledge of Elementary Arithmetic….Teachers soon discover that though anxious to learn, a student of this kind does not want to lose contact with the practical requirements of the workshop - he is impatient of pure mathematics….It will consequently be found that the most prominent characteristics of the present book…is the subordination of rigid mathematical proof to the provision of numerous examples drawn from the student's everyday experience" (pp. v-vi).

The classism underpinning the distinction between pure and applied mathematics is clear, and parallels with the South African apartheid education system that sought to prepare racial groups differently for their presumed working lives are evident. The field of mathematical literacy has developed considerably since the useful/esoteric distinctions and the variety of definitions offered and discussed below is indicative of the development of the field.

2.1.2 What is mathematical literacy - some suggested definitions

Definitions of the concept of mathematical literacy, under the names of numeracy, matheracy, and quantitative literacy have been suggested and debated for several decades. Kaye (2002) compiled a nineteen page document documenting the definitions of numeracy discussed by delegates attending the previous eight Adults Learning Mathematics (ALM) Conferences. Overall, he notes that there is a growing awareness of the insufficiency of traditionally defined mathematics skills in preparing individuals to operate powerfully in the twenty-first century.

Table 2.1 provides definitions of mathematical literacy and related terms starting from the 1959 Crowther Report (Central Advisory Council for Education, 1959) to the 2006 definition arising from the PISA study (OECD, 2006) which seems to have gained general acceptance. The main definitions are discussed in the ensuing sections, showing the development from basic arithmetic to sophisticated quantitative reasoning.

Numeracy

The initial reference to numeracy in the Crowther Report was as a mirror image to literacy (Central Advisory Council for Education, 1959). Just as the field of traditional literacy, i.e. basic reading and writing, has been expanded to include ideas of "multiliteracies" and "situated literacies" and the social context of literacy is highlighted in the literature (Barton, Hamilton, & Ivanic, 2000; Cope & Kalantzis, 2000) so has the initial idea of numeracy (simple working with numbers) been expanded. In the 1930s John Dewey (cited in Steen, 2001) spoke of literacy as popular enlightenment meaning that which enables people to think for themselves, judge independently, and discriminate between good and bad information, as opposed to the passive literacy of being able to understand instructions and carry out procedures routinely. Moreno (2002) contends that the popular enlightenment notion would apply equally well to statistical literacy and numeracy. Fitzsimons, Coben and O'Donoghue (2003) observe that "the purely functional notion of numeracy has been rejected by most modern researchers in favour of the notion of empowering learners through numeracy, either for personal development or critical citizenship" (p. 120). If the definition of innumeracy offered by Paulos (1988) is reversed, the resulting description of numeracy is the ability to deal comfortably with the fundamental notions of number and chance. The interchangeable use of numeracy and mathematics in the primary school sector in England reinforces the conception of numeracy as a set of very minimal and low-level number skills, and for this reason an alternative name is preferred to signal the inclusion of a broader scope and more sophisticated competences.

Critical mathematics education/ critical mathematical literacy

In 1983, Frankenstein (1983), in her words, "re-invented" Paulo Friere's critical education theory in the context of a mathematics curriculum for urban working-class adults in order to provide a theoretical foundation for her practice. She concluded that critical mathematics education "compels teachers to probe the nonpositivist meaning of mathematical knowledge, the importance of quantitative reasoning in the development of critical consciousness, the ways in which math anxiety helps sustain hegemonic ideologies, and the connections between our specific curriculum and the development of critical consciousness" (Frankenstein, 1983, p. 324). More recently, de Freitas (2004) has challenged the common assumption that mathematics is apolitical and free from entrenched ideological motives. A strong feature of the pedagogy of critical mathematics is the use of real, or at least realistic, problems to provide contexts for mathematical learning, and raise critical awareness of social, economic and political issues. This early work was extended and reported fifteen years later using the designation critical mathematical literacy (Frankenstein, 1998). The focus remained on the use of mathematics as a tool to interpret and challenge societal inequities.

Quantitative Literacy

The earliest reference I have found to quantitative literacy is 1993 when it was used in the context of a national adult literacy survey. The definition provided (see Table 2.1) is clearly rooted in the domain of number skills as mention is made only of arithmetic operations and commercial type arithmetic. Critics of the term quantitative literacy feel that it is too closely associated with numbers and data, and does not point to competences associated with algebra, geometry and measurement, nor more significantly to personal, social and political empowerment.

Matheracy

One can infer that the term matheracy was coined to imply a mathematically related extension from the numbers aspect of numeracy. According to D'Ambrosio (1998), matheracy is similar to the way mathematics was presented in classical Greece, with a stronger focus on philosophy than on counting and measuring. Skovmose (2004) concedes that the notion of matheracy is complex and cannot be depicted within a well elaborated definition. It involves a concern for empowerment and the intent to develop a practice of mathematics education with a critical dimension.

Mathematical literacy

As with matheracy in place of numeracy, so mathematical literacy has a wider connotation than quantitative literacy which to some minds implies a concern with numbers and data. The 2006 definition provided in the context of the PISA study (OECD, 2006) includes an appreciation of mathematics as discipline and tool (identify and understand the role that mathematics plays in the world), higher order reasoning skills (making well-founded judgements), and an application of mathematics to everyday social, working and political life (engage with mathematics in ways that meet the needs of that individual's life).

Table 2.1 Evolving definitions of mathematical literacy

Date	Source	Term	Definition
1959	Crowther Report; England.	Numeracy	In its report the committee said that "numeracy" should "represent the mirror image of literacy." It should imply "on the one hand…an understanding of the scientific approach to the study of phenomena…"and "on the other hand…the need in the modern world to think quantitatively, to realize how far our problems are problems of degree even when they appear as problems of kind". (Central Advisory Council for Education, 1959, par 401)
1982	Cockcroft report; England	Numeracy	We would wish numerate to imply the possession of two attributes. The first of these is a 'at -homeness' with numbers and an ability to make use of mathematical skills which enable an individual to cope with the practical mathematical demands of everyday life. The second is ability to have some appreciation and understanding of information which is presented in mathematical terms, for instance in graphs, charts or tables or by reference to percentage increase or decrease. (Cockcroft, 1982, par 39)
1983	Frankenstein; USA	Critical mathematics education	Critical mathematics education "compels teachers to probe the nonpositivist meaning of mathematical knowledge, the importance of quantitative reasoning in the development of critical consciousness, the ways in which math anxiety helps sustain hegemonic ideologies, and the connections between our specific curriculum and the development of critical consciousness" (Frankenstein, 1983, p. 324)
1985	D'Ambrosio; Brazil Skovmose; Denmark	Matheracy	Matheracy is the capability of drawing conclusions from data, inferring, proposing hypotheses and drawing conclusions. It is a first step towards an intellectual posture… Mathemacy is closer to the way Mathematics was present in both classical Greece and in indigenous cultures. The concern was not with counting and measuring, but with divination and philosophy. Mathemacy, this deeper reflection about man and society, should not be restricted to the elite, as it has been in the past.
1988	Paulos: America	Innumeracy	Innumeracy is an inability to deal comfortably with the fundamental notions of number and chance. (Paulos, 1988)
1993	National Adult Literacy survey: America	Quantitative Literacy	The knowledge and skills required to apply arithmetic operations, either alone or sequentially, using numbers embedded in printed material (e.g. balancing a checkbook, completing an order form)
1997	OECD; International	Quantitative Literacy	The knowledge and skills required to apply arithmetic operations, either alone or sequentially, to numbers embedded in printed materials, such as balancing a checkbook, figuring out a tip, completing an order form, or determining the amount of interest on a loan from an advertisement.
2000	ILSS: International	Quantitative Literacy	An aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work.

Date	Source	Term	Definition
2000	OECD (PISA); International	Mathematical Literacy	The capacity to identify, to understand and to engage in mathematics and to make well founded judgements about the role that mathematics plays, as needed for an individual's current and future life, occupational life, social life with peers and relatives, and life as a constructive, concerned and reflective citizen.
2000	Evans; England	Numeracy	Numeracy is the ability to process, interpret and communicate numerical, quantitative, spatial, statistical,, even mathematical information, in ways that are appropriate for a variety of contexts, and that will enable a typical member of the culture or subculture to participate effectively in activities that they value.
2000	Devlin; America	Quantitative Literacy	Roughly speaking, quantitative literacy-sometimes called numeracy- comprises a reasonable sense of number, including the ability to estimate orders of magnitude within a certain range, the ability to understand numerical data, the ability to read a chart or graph, and the ability to follow an argument based on numerical or statistical evidence
2003	Bass Forum summary; America	Quantitative Literacy	In our collective minds, QL appears to be some sort of constellation of knowledge, skills, habits of mind, and dispositions that provide the resources and capacity to deal with the quantitative aspects of understanding, making sense of, participating in, and solving the problems in the worlds that we inhabit, for example, the workplace, the demands of responsible citizenship in a democracy, personal concerns, and cultural enrichment.
2003	Department of Education South Africa	Mathematical Literacy	Mathematical Literacy provides learners with an awareness and understanding of the role that mathematics plays in the modern world. Mathematical Literacy is a subject driven by life-related applications of mathematics. It enables learners to develop the ability and confidence to think numerically and spatially in order to interpret and critically analyse everyday situations and to solve problems. (Department of Education, 2003)
2006	OECD (PISA); International	Mathematical Literacy	An individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen. (OECD, 2006, p. 12)

Concluding remarks

Despite the different connotations and origins of the terms used to describe mathematical literacy and the personal preferences authors may have regarding their use, it is common practice to use the terms numeracy, matheracy, quantitative literacy and mathematical literacy almost interchangeably. For example, Bishop writes: "developing numeracy, or 'matheracy' as D'Ambrosio prefers to call it (meaning mathematical literacy)…" (2000), using three of the terms as alternatives. Kaiser and Willander (2005) note that there does not seem to be consensus about the differences between mathematical literacy, quantitative literacy and numeracy and which is the more general concept. Advocates of each name claim that their preferred name, at least as they define it, is not limiting. For example, Tout, (cited in Kaye, 2002) claims that the Australian use of numeracy connotes a high level of sophistication, and, as the following quote indicates, includes the ideas of matheracy and mathematical literacy: "We believe that numeracy is about making meaning in mathematics and being critical about maths….It is about using mathematics in all its guises - space and shape, measurement, data and statistics, algebra, and of course, number - to make sense of the real world, and using maths critically and being critical of maths itself. It acknowledges that numeracy is a social activity. This is why we can say that numeracy is not less than mathematics but more. It is why we don't need to call it critical numeracy - being numerate is being critical" (Kaye, 2002, ALM 3 Dave Tout section).

In line with the common practice in South Africa, I will use the term mathematical literacy, in its most inclusive sense, in this thesis.

2.1.3 Advocacy for Mathematical Literacy

As long as twenty five years ago, people were writing about the tension between applied and pure mathematics, the challenge of increasing numbers of mathematically underprepared college students, the importance of mathematical literacy and the difficulties faced by women and mathematically anxious students (Steen, 1981). The issues are thus not new, but the swell of support for mathematical literacy has grown, driven both by those with the practicalities of life in mind and those for whom democratic citizenship and political empowerment are key issues.

Mathematical literacy for self-managing persons and productive workers

Advocacy of mathematical literacy is based firstly on the obvious practical value of being able to deal with quantitative situations in personal and work situations. In the seminal article making the case for quantitative literacy, Steen (2001) describes in detail how "professionals in virtually every field are now expected to be well versed in quantitative tools" (p. 12) and how almost all fields of education now require some quantitative literacy. Personal management of health and finances are also increasingly dependent on sophisticated understandings of number and statistics. There is little argument on this score - everybody can appreciate the disempowering effect of a poor understanding of number, measurement and simple statistics in the day to day lives of ordinary people. Statisticians have joined in advocating mathematical literacy. This was emphasised by the theme of the Sixth International Conference on Teaching Statistics in 2002, namely "Developing a Statistically Literate Society" where speaking of statistical literacy, Schield (2002) noted that "anybody lacking this type of literacy is functionally illiterate as a productive worker, an informed consumer or a responsible citizen" (p. 41). The latter role suggests a second and perhaps less obvious motivation for a mathematical literacy programme, i.e. to develop the quantitative literacy required for responsible citizenship in a democracy.

Mathematical literacy for responsible citizenship

Cohen (2003) contends that dating back to the early 19th century the links between democratic government and political arithmetic have been threefold: (a) the political legitimacy of a representative democracy rests on counts and proportional reasoning; (b) a government needs good aggregate data about its citizens to make policy decisions for the greater good; and (c) the citizens in a democracy need good data in order to judge the decisions made by the government and express this judgement through their vote. In the course of the 19th century, the field of statistics developed along with a public enthusiasm for statistical almanacs filled with facts and figures about "banks, canals and railroads, pupils and schools" (Cohen, 2003, p. 14). However, by the 20th century, the growing sophistication of statistical information "quickly outstripped most consumers' abilities to comprehend" (p. 15). Indeed, as Cohen remarks: "Both the politicians and the voters may be in over their heads when it comes to evaluating different projections on the future of Social Security, the differential and future effects of tax cuts, the flow of immigration into the country, the rising and falling of student test scores, and the gyrations of the stock market as summarised in a few one-number indexes reported hourly on the radio. The danger is that we may not realize that we are in over our heads" (pp. 16-17).

"The combined thrust of (economic and statistical) literacies enables individuals and societies to act both at the economic and political fronts through social discourse. Economic literacy is predicated upon, and intricately intertwined with, statistical literacy" (Lehohla, 2002, p. 1). It cannot, of course, be assumed that all politicians would seek to promote such literacies. Lehohla (2002) reminds us that the social and public policy of the apartheid era deliberately, or otherwise, controlled how official statistics were to be collected, interpreted and disseminated and those in control were unlikely to have advocated general statistical literacy.

Niss (2003) notes that "traditionally, we tend to see the role of mathematical literacy in the shaping and maintenance of democracy as being to equip citizens with the prerequisites needed to involve themselves in issues of immediate societal significance" (p. 216). Such issues could range from broad political, economic and environmental concerns, through community issues and down to the concerns closer to an individual such as wages, insurance, bank rates and child care costs. He proposes, however, that the role of mathematical literacy in a democracy not be confined to the competence to deal with quantitative societal issues, but be expanded to encompass more philosophical issues: "For democracy to prosper and flourish, we need citizens who not only are able to seek and judge information, to take a stance, to make a decision, and to act in such contexts. Democracy also needs citizens who can come to grips with how mankind perceives and understands the carrying constructions of the world….It is a problem for democracy if large groups of people are unable to distinguish between astronomy and astrology, between scientific medicine and crystal healing, between psychology and spiritism, between descriptive and normative statements, between facts and hypotheses, between exactness and approximation, or do not know the beginnings and the ends of rationality, and so forth and so on. The ability to navigate in such waters in a thoughtful, knowledgeable, and reflective way has sometimes been termed 'liberating literacy' or 'popular enlightenment.' As mathematical literacy is often at the centre of the ways in which mankind perceives and understands the world, mathematical literacy is also an essential component in liberating literacy and popular enlightenment" (Niss, 2003, p. 217).

This wider description of the link between mathematical literacy and democracy resonates more with the concept of matheracy than the generally accepted ideas of numeracy or quantitative literacy. Given the consensus on the value of mathematical literacy, the next issue relates to how to develop and nurture this in the population at large. This depends largely on whether mathematical literacy is seen as a personal competence or habit of mind, as a subject to study, or, as in the South African context, as both.

2.1.4 Mathematical Literacy - a habit of mind or a subject to study?

The test of quantitative literacy, as of verbal literacy, is whether a person naturally uses appropriate skills in many contexts (Steen, 1999). In its original conception, and from the definitions in Table 2.1, it is evident that mathematical literacy is a human attribute and a hoped for by-product of sound mathematics education in the compulsory schooling curriculum. Anecdotal reports from all sectors of tertiary education testify to the absence of the desired by-product. The choice is clear: either (a) expand the scope and pedagogy of traditional mathematics to include practice in quantitative reasoning and critical use of mathematics, or (b) to keep the mathematics as the pure discipline and create another subject.

Including mathematical literacy in mathematics

Madison (2004, p. 10) characterises school mathematics as a "hurried and linear sequence of geometry, algebra, trigonometry, and calculus…underwritten by the perceived educational needs of future scientists, engineers and mathematicians" (p. 10). Steen (1999) concurs that school mathematics, as traditionally taught, is not necessarily the best way to promote mathematical literacy: "Despite widespread evidence that numeracy is more than mathematics and that practical wisdom is not the same as classroom learning, anxious parents and politicians push students into the narrow gorge of early algebra and high school calculus in the misguided belief that these courses provide the quantitative skills appropriate for educated citizens. By and large, they do not. .....Numeracy, not calculus, is the key to understanding our data-drenched society" (p. 9).

Quantitative literacy is both more than and different from mathematics - at least mathematics as it has traditionally been viewed by school and society. Madison (2004), rather than advocating a separate subject, suggests that the mathematics at schools and colleges be changed in nature and content to be more in service of quantitative literacy. He acknowledges four main arguments against such a change:

1. Quantitative literacy is difficult, not so much in the mathematical content as in the applications of the mathematics. The difficulty of quantitative literacy, however, is rooted in its sophisticated uses of elementary mathematics in multiple and unpredictable contexts.
2. Quantitative literacy, being a habit of mind more than a set of procedures, cannot be taught.
3. Education systems are notoriously difficult to change and so the hope of making major changes in American education is unrealistic.
4. Emphasising Quantitative literacy will harm mathematics. "They fear that teaching contextualised mathematics will water down the mathematics, that far fewer

students will learn the formal mathematics required for science and engineering" (Madison, 2004, p. 12).

He provides convincing arguments against each of these. For example, countering the first of these arguments, Madison (2004), contends that practice in the application of quantitative literacy in a variety of contexts will aid recognition of its appropriate use and reduce the level of difficulty. Furthermore, many habits of mind such as creative writing or critical thinking are successfully taught and so in principle, this is not a valid argument against teaching quantitative literacy. The alternative to blending the two mathematics to the satisfaction of all, is to have split streams with no easy way of moving between them. We then run the risk of the accusation that "the lower status of the quantitative literacy route leads to accusations from equity advocates who fear that some groups will be channelled into dead end tracks" (p. 12). Nevertheless the "separate subject" option has been adopted, notably in South African senior secondary schools.

Mathematical literacy as a separate subject

The dilemma is to decide on the relationship between mathematics and mathematical literacy and to answer the question posed by Stoessiger (2003); as to whether mathematics and mathematical literacy are subsets (either way) or disjoint sets, or perhaps intersecting sets. Furthermore, Madison (2004) answers his own question: "Why trade knowledge of an ancient discipline with centuries of contributions to society for something we barely understand and have little evidence we can teach?" (p. 12) by concluding that the motivation is because so much is at stake.

Choosing to have separate subjects opens a question of status, and current popular understanding unfortunately trivialises the subject mathematical literacy as indicated in the following explanation in a widely read magazine and in the press: "The grading system was for learners who didn't make the grade in difficult subjects such as maths and science. Learners who previously could only pass maths on the lower grade can now simply take mathematical literacy, which is less abstract than pure maths" (Booyens, 2002, p. 21). Such impoverished views of mathematical literacy are found even among teachers of the subject. For example, Mbekwa (2006) reports research conducted with a cohort of twenty teachers at University of the Western Cape retraining to teach Mathematical Literacy in schools. One of the research questions related to the teachers' common sense understanding of mathematical literacy. The understandings seemed to fall into categories: (a) the functionalist view which regards mathematical literacy as that type of mathematics that finds application in people's lives, and (b) the view which regards mathematical literacy as an easier version of traditional school mathematics. The latter view predominated.

There is however, at least one reason for a dedicated mathematical literacy subject. Schooling is a not a universally successful enterprise and mathematics education in particular fails many students. Steen (1990) drew the analogy of a refinery to illustrate the passage of students through American schools in the late twentieth century: "The pipeline of mathematics students that flows from kindergarten to graduate school is more like a refinery than a simple pipeline: open valves here and there drain away valuable talent; clogged filters in certain parts prevent normal flow; and feedback loops at crucial junctions permit students to become teachers while still being students" (p. 131). Steen (1990) reported that from the ninth grade, half the students were lost each year, with Blacks and Hispanics dropping out early, and women dropping out later but still disproportionately. Perhaps a separate subject, would close some valves and keep students engaged with mathematical ideas longer.

2.1.5 Summary

In this section the international origins of "useful mathematics" have been traced through history and the debates surrounding the nomenclature discussed. Putting aside those debates, the strong arguments in favour of increased emphasis on mathematical literacy were presented, concluding with the practical debate about the positioning of mathematical literacy in relation to formal school mathematics. These international debates form the backdrop to the positions adopted by South African policy makers regarding mathematical literacy in schools and tertiary institutions.

2.2 SOUTH AFRICAN NATIONAL PERSPECTIVES

The current South African school curriculum has a strong agenda of social transformation and redress of the past disadvantages experienced by many learners under the apartheid regime (Department of Education, 2003, p. 2). In 2003, more than forty percent of South African learners attended schools rated by teachers and principals as having a low resource base for mathematics teaching and learning, a low school climate and low school and class attendance (Reddy, 2006b). In particular, the poor state of primary mathematics education in many schools had led to learners discontinuing their study of mathematics at Grade 9 level "thus contributing to a perpetuation of high levels of innumeracy" (Department of Education, 2003, p. 9), and the introduction of mathematical literacy was designed to "ensure that our citizens of the future are highly numerate consumers of mathematics" (Ibid, p.9).

2.2.1 Mathematical Literacy in the context of the Further Education and Training band

The South African school curriculum has two bands; the General Education and Training (GET) Band for Grades R-9, and the Further Education and Training (FET) Band for Grades 10 -12. The GET band is compulsory and the State intention is that all children should complete these nine years of schooling and then choose a FET path depending on their ability and aptitude. This has to be seen in the context of the National Qualifications Framework (NQF) which includes levels for non-traditional schooling such as Adult Basic Education (ABET) which has four levels to reach NQF Level One. Thereafter the NQF Levels are common to schooling, technical and vocational education and continue past schooling level through tertiary education to NQF Level 8. The curriculum debates around Mathematical Literacy come after the compulsory GET phase when learners may elect to go into the academic stream and remain at traditional schools, or transfer to FET colleges which offer more vocational training. In the academic stream, Mathematical Literacy is provided as an alternative to formal mathematics, and in the FET Colleges, Mathematical Literacy must be studied to a certain level regardless of the vocational course chosen. This structure is summarised in Table 2.2, with learners progressing through the levels from the bottom of the table upwards.

Table 2.2 Mathematics and Mathematical Literacy in the National Qualifications Framework

	Level	Mathematics	Mathematical Literacy
Further Education and Training	NQF 4 NQF 3 NQF 2	Algebra, geometry, trigonometry, logarithms, calculus, sequences, series	Applications of NQF 1 in increasingly complex situations.
General Education and Training	NQF 1	Mathematics and Mathematical Literacy	
	ABET 4 ABET 3 ABET 2 ABET 1	Number concept (whole, negative, fractions, decimals) and applications involving: the four operations, average, ratio, proportion, percentage, measurement, area, volume, graphs, data, shapes, space, formulae, patterns, simple relationships …	

Although in South Africa we have a separate subject called Mathematical Literacy, it is hoped that learners doing the subject Mathematics would also emerge mathematically literate. Hallendorff, (2003) however, points out that there is little development in arithmetical skills (and Mathematical Literacy) beyond NQF1/Grade 9 through mathematics alone. In his survey of the debates surrounding the introduction of mathematical literacy as a school subject, Hallendorff, (2003) further noted that there was consensus among the stakeholders that while it is important to develop people mathematically up to NQF 1, not all people will necessarily need to be developed mathematically beyond this level. What is important is to develop mathematical literacy, not as a watered down version of mathematics, but as the application of NQF 1 mathematics in various contexts, of varying complexity. In this sense, mathematical literacy can progress in complexity from NQF 2 to NQF 4, even though the mathematics content and skills remain at Level 1.

The task of the curriculum team was to translate the level descriptors produced by the Standards Generating Body (SGB) into a sensible curriculum for schools (or Further Education Certificates in technical and vocational fields). The level descriptors, outlined in Table 2.3, reflect minimum expectations at each level with Level 4 expectations being worked towards at lower levels.

In the schooling context, the FET subject, Mathematical Literacy, aims to enable the learner to become a self-managing person, a contributing worker and a participating citizen in a developing democracy (Department of Education, 2003, p. 10). The self managing person must, for example, deal with financial matters, timetables and household matters involving measurement; the contributing worker must develop the numeracy necessary to deal with work-related formulae, schedules, charts and understand instructions involving numerical components; and a participating citizen in a democracy should have the ability to take a critical stance towards quantitative arguments used to promote particular political viewpoints.

The contexts in which skills of mathematical literacy must be developed are those relevant to the adolescent and young adult. Examples cited in the curriculum document (Department of Education, 2003) include comparing different credit options in Grade 12 (p. 19), and drawing graphs of the number of AIDS-related deaths and deaths caused by malaria over time, on the same system of axes to describe the extent of the AIDS epidemic (Grade 12, p. 23). These contextualized examples can be complex and politically loaded and Bass (2003) cautions us that:"…much contextualised curricular mathematics presents artificial caricatures of contexts that beg credibility.

Table 2.3. Level Descriptors Proposed by the FET SGB Task Team

	Level 2	Level 3	Level 4
Mathematics	Mathematics from the GET Band together with what is required in the range statements of the Specific Outcomes for mathematical literacy at this level.	Mathematics from the GET Band together with what is required in the range statements of the Specific Outcomes for mathematical literacy at this level.	Mathematics from the GET Band together with what is required in the range statements of the Specific Outcomes for mathematical literacy at this level.
Applications	Well defined routine problems set within real life, cultural and societal contexts relevant to teenagers. To deepen appreciation of the use of mathematics in real life situations Applicable in the potential and actual workplace	Familiar non-routine problems set within real life, cultural, societal and political contexts relevant to the young adult. To deepen appreciation of the use of mathematics in more complex real life situations Applicable in the potential and actual workplace	Open-ended problems within a broader set of real life parameters; cultural, societal and political contexts relevant to the young responsible adult. To deepen appreciation of the use of mathematics in complex real life situations Applicable in the potential and actual workplace
Cognitive demand	Recall Reproduce Give an opinion Make a conjecture	Summarise Gather information Interpret Argue for a position Justify	Gather information Critique Communicate reliably Make judgements Prove
Societal concerns	Peer groups The school/workplace community Teen concerns	The broader community Small business Young adult concerns	Country Concerns of the young adult with increasing responsibilities

Either many of their particular features, their ambiguities, and the need for interpretation are ignored in setting up the intended mathematics, which defeats the point of the context, or else many of these features are attended to and they obscure the mathematical objectives of the lesson" (p. 248).

Whilst the aims stated above have been generally lauded, the introduction of mathematical literacy as a school subject has been contested mainly due to practical concerns that there are inadequate resources for successful implementation. Clearly, the implementation problems will be most keenly felt in disadvantaged schools, where learners could find their school leaving certificates jeopardised by the requirement of a pass (even at the minimal suggested level of 30%) in Mathematical Literacy. It is clear from Table 2.2 that Mathematical Literacy builds on a sound understanding of the mathematics learnt in the GET phase of schooling.

The compelling evidence (see for example Hobden, 2006; Howie, 1997b; Reddy, 2006b; Taylor & Vinjevold, 1999) is that the GET level mathematics has not been mastered to any acceptable level by many learners in South African schools. Furthermore, the notion of mathematical literacy as a sophisticated competence is undermined by a public perception of the school subject as being practical and easy arithmetic. Now that the school subject is in place, concern must be raised by press reports which describe how learners are taught "how to work out a budget, interest rates on loans and even how to measure the correct amount of flour needed to bake a cake" (Keating, 2006). In the same article, a school principal is quoted as saying his pupils were doing quite well and were at the time being taught how to convert rands into cents. One can only hope he is mistaken as the competence "solves money problems … including converting between rands and cents" occurs as a Grade 3 Assessment Standard (Department of Education, 2002, p. 21).

It is against the backdrop of these debates and developments around mathematical literacy that the faculties at universities made decisions around the numeracy requirements of the undergraduate students. Of particular relevance to this study are the decisions made by the education faculties.

2.3 MATHEMATICAL LITERACY IN THE CONTEXT OF PRESERVICE TEACHER EDUCATION

Teacher education in South Africa is undertaken by Higher Education institutions such as universities and technikons, and regulated by government policy set by the national Department of Education and the South African Qualifications Authority as described below.

2.3.1 National Teacher Education Policy:

The national policy document for teacher education, (Department of Education, 2000a), sets out seven roles for teachers. These play an important part in determining the curricula for state-funded preservice teacher education programmes which are committed to developing proficiency in each role. Teachers must be competent to fulfil the roles of learning mediator; interpreter and designer of learning programmes and materials; leader, administrator and manager; scholar, researcher and lifelong learner; community, citizenship and pastoral role, assessor; and learning area /subject /discipline/ phase specialist. Careful study of the document reveals a single line under the heading of the scholar, researcher and lifelong learner role (Practical competences) in which we read that learners (in this case preservice teachers) must be demonstrably numerically, technologically and media literate. This is a direct reference to mathematical literacy within teacher education. The relevant section of the document is reproduced in Figure 2.2 to provide an idea of the other associated competences.

Scholar, Researcher and Lifelong Learner **Practical competences**
(Where the learner demonstrates the ability, in an authentic context, to consider a range of possibilities for action, make considered decisions about which possibility to follow, and to perform the chosen action.)
Being numerically, technologically and media literate.
Reading academic and professional texts critically.
Writing the language of learning clearly and accurately.
Applying research meaningfully to educational problems.
Demonstrating an interest in, appreciation and understanding of current affairs, various kinds of arts, culture and socio-political events.
Upholding the principles of academic integrity and the pursuit of excellence in the field of education.

Figure 2.2. Extract from Norms and Standards for Educators (Department of Education, 2000a)

The detail of these competences is provided by a document produced by the other government regulating body, South African Qualifications Authority (SAQA), which had the responsibility for creating a national qualifications framework.

2.3.2 National Qualifications Framework:

The academic demand of the Bachelor of Education degree is prescribed at a national level by a statutory body, South African Qualifications Authority (SAQA), and must be in line with the generic exit level outcomes prescribed for a qualification at NQF Level 6. These were elaborated and contextualised into four components specifically for this degree in a General Notice in the Government Gazette (South African Qualifications Authority, 2001), these being competences relating to fundamental learning; the subject and content of teaching; teaching and learning processes; and the school and educator profession. The competences in the first component describe the language and quantitative skills that all teachers should possess for their own personal and professional use in teaching. The second component is concerned with the demonstration of competence with regard to the knowledge base underpinning the learning of a particular subject and in planning, designing, and reflecting on learning programmes appropriate for their learners and learning context. The exit level outcomes listed under the third component are directly related to the classroom - the establishment of a suitable learning environment, and design and selection of learning activities and assessment, while those under the fourth component concern the engagement of the preservice teacher with issues of the teaching profession as a whole. These four components provide a framework on which to build a teacher education programme, and also provide a guide for the academic demand of individual modules.

Of particular relevance here is Component 1, competences relating to fundamental learning, where the focus is mainly on the role of scholar, researcher and lifelong learner, with some application to learning mediation, assessment and management. Exit level Outcome 2 of Competence 1 requires the preservice teacher to "demonstrate competence in interpreting and using numerical and elementary statistical knowledge to facilitate their own academic learning, and to manage teaching, learning and assessment" (p. 2). The performance indicators suggest that the candidates should be able to apply their understanding of numeracy and basic statistics to, among other things, monitor and report on learners' progress, interpret numerical data relating to psychological assessment of learners and use elementary procedures for financial management. Sixty credits (of the total 480 allocated to a B.Ed degree) are prescribed as the minimum for the Fundamental Learning Component, with a possibility of an additional 48 credits being utilised if the context and needs of the students make it necessary.

Clearly, the national government intention is that mathematical literacy be part of the preservice teacher education programmes and that all preservice teachers will achieve the mathematical literacy they need for their ordinary lives and their professional lives as teachers before they graduate. The extent of this challenge was alluded to in the recent report of the Ministerial Committee on Teacher Education (Department of Education, 2005). This committee was constituted in 2003 to draw up a national framework for teacher education in South Africa. After extensive consultation with stakeholders and site visits to the 22 Higher Education institutions that offer teacher education, a report was published in June 2005. On the matter of mathematical literacy (referred to in the report as numeracy) they reported: "It has to be acknowledged that many students in initial teacher education programmes have very poor levels of (print) literacy and numeracy….Programmes need to focus sharply on this issue, and emphasize the development of student teachers' levels of literacy and numeracy across the whole curriculum, if for no other reasons than to enable teachers to continue to learn from reading" (Department of Education, 2005 p.13).

This seems to indicate that some of the responsibility for developing mathematical literacy will have to be assumed by other subjects and not remain the sole duty of the mathematics department. However, the Higher Education institutions undertaking initial teacher education have some flexibility in the design of their degree programmes, providing they keep to the framework. The interpretation and response of the institution in which this research took place is outlined below.

2.3.3 University of KwaZulu-Natal Bachelor of Education Policy

The Faculties of Science and Engineering, for example, have entrance requirements that specify good passes in Grade 12 mathematics. Presently though, students entering the Faculties of Law, Humanities and Education may have done so without a pass in Grade 12 mathematics. This is interpreted by the university as being inadequate to satisfy the requirement of sufficient numerical skills alluded to above, and each faculty has in place numeracy type modules to make up the deficit. For example, the Law faculty runs a numeracy module based on materials prescribed by the Law Society, for aspirant lawyers who have lower than a C on Standard Grade for mathematics at school level. The requirements and policy of the Education faculty in this regard are discussed here as they are of particular relevance to this study.

The Education faculty has the responsibility of preparing teachers to practice professionally in South Africa. The initial teacher education degree is a four year Bachelor of Education, with slightly different curricula depending on the school phase in which students intend to specialise. Students wishing to teach in the Foundation and Intermediate Phases are compelled to do three modules of Primary Mathematics Education as the national policy favours generalist teachers in these phases. Those who enter the degree without a pass in Grade 12 mathematics must pass a foundational module named Basic Mathematics before continuing with their primary mathematics education studies. However, students wishing to teach in the Senior and FET phases specialise in particular subjects or learning areas. Those who have not passed Grade 12 mathematics obviously cannot chose to be mathematics teachers, but nevertheless they are required to pass a module which will help them to cope with the mathematical demands of their personal, and more particularly, their professional lives. This policy was introduced in 2003, and a new module (specifically for secondary level non-mathematics specialist preservice teachers) called Mathematical Literacy for Educators (MLE) was introduced into the Bachelor of Education curriculum. The development of this module in terms of curriculum, staffing, teaching and learning over the three years to the end of 2005, is explained in the following section.

2.4 MATHEMATICAL LITERACY FOR EDUCATORS MODULE PERSPECTIVES

This discussion of the first three years of the MLE module, charts the journey from its onset through several changes of style, approach and content made in response to the researcher's reflection on the course and in the light of changing institutional circumstances. The detailed description here will help the reader to understand the local context in which the research occurred.

2.4.1 <u>MLE module information</u>

In 2002, the Bachelor of Education curriculum was revised and those preservice teachers intending to specialise in primary school phases, and who did not have a pass in Grade 12 mathematics were required to do a foundational mathematics module. At the same time, the school curriculum reform for the FET was moving ahead and the implementation of Mathematical Literacy as a compulsory subject for those not electing to study mathematics to Grade 12 was imminent. I decided to do a pilot study using all the first year BEd students asking them about their school experience of mathematics and reasons for choosing it as a subject or not. The results of this study were reported in a paper in early 2002 (S. Hobden, 2003). In the course of that study, I found only about 12 preservice teachers, intending to be secondary teachers who did not have a pass in Grade 12 mathematics and so confidently expected a small group of about 20 in the initial MLE module in 2003, but in the event there were 71 students.

Table 2.4 Mathematical Literacy for Educators module information 2003 - 2005.

Module information	2003 $n = 71$	2004 $n = 143$	2005 $n = 69$
Teaching staff	Mrs Hobden Mrs Rosenberg PGCE student tutors	Mrs Hobden John, Matthew, Kirsty and Debbie (student tutors)	Mrs Hobden Mrs Reddy (occasional tutor) Grant and Adam (video technicians and occasional tutors)
Lectures	Choice of 3 or 4 optional tutorial times (tutors	1 double plenary 1 single plenary 1 with tutors Choice of 4 or 5 optional tutorial times (tutors)	2 double plenary Occasional 1 single plenary, 1 tutorial Choice of 3 optional tutorial times (S.H.)
Resources	Printed notes (given out piecemeal)	Printed notes Skills building packs Workbook activities	Printed notes Skills building packs Workbook activities (all given as a pack) Independent learning CD Books on reserve in library Videos of lectures
Course Content	Nature of maths Maths reasoning Number Measurement (inc decimals) Financial maths Data Handling	Nature of maths Number Measurement (inc decimals) Data Handling	Nature of maths Number Measurement (inc decimals) Financial maths Data Handling
Assessment	Class activities Tests (and retests) Statistics project Final exam	Class activities Tests Statistics project Final exam	Fewer class activities Tests Statistics project Final exam

In 2004, arising from the merger with the University of Durban-Westville there was a combined first year intake. We had been assured that the quality of student enrolment would be higher than previously which would have meant fewer students without a Grade 12 pass in mathematics and so once again I expected a smaller class. There was some confusion between the two campuses over the enrolment and delays in getting students registered. Each MLE lecture in the first weeks saw half a page of new names added to the register until I had to negotiate a move to the biggest lecture theatre on campus to accommodate my eventual class of 143. By 2005 I was ready for a surprise but the intake was, as expected, smaller and the class size dropped down to 69 again. Table 2.4 summarises the module staffing, contact time, resources and content over the years:

2.4.2 Preservice teachers in the MLE module

At the heart of this study lie the preservice teachers who grappled with the course content with varying degrees of success. Over the three years, there were a total of 283 registrations, but adjusting for the 29 students who repeated the module, there were 254 different people. Who were these people? Taken all together the three cohorts formed a very diverse group aged from 17 to 45, representing all race groups in South Africa, both genders and coming from schools ranging from exclusive private boarding schools to the poorest rural schools. What they had in common was an unsuccessful mathematics background. Table 2.5 is a summary of the biographic attributes of the preservice teachers in all three cohorts. Each attribute is discussed separately in the sections that follow.

Figure 2.3 shows the age distribution for the three cohorts of preservice teachers. In each of the three years the mean age rounded to 23 years. The mean is however skewed by the outliers as there were several students in their thirties or forties. About half of each cohort was aged between 18 and 21 which is typical for first year students.

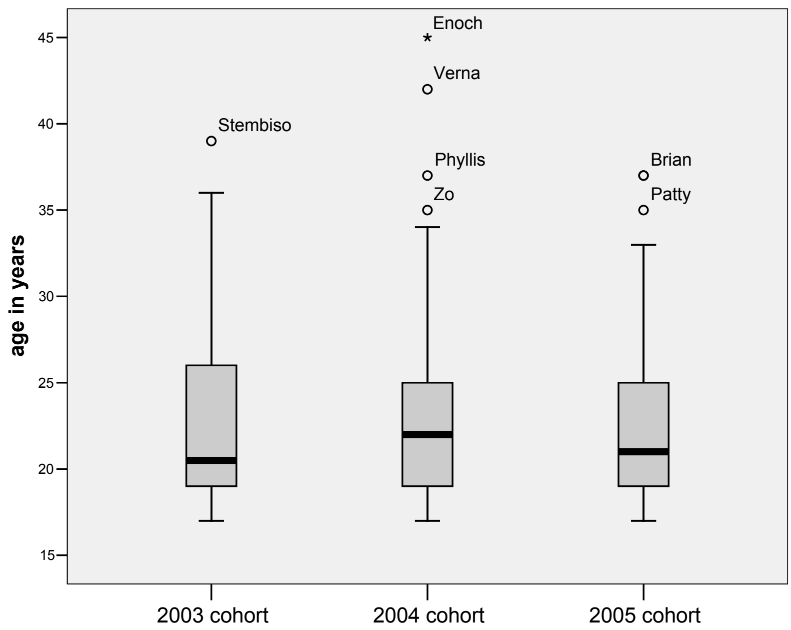


Figure 2.3 Age distribution of preservice teachers in MLE module

Table 2.5 Biographic data from all preservice teachers in the study

Biographic attribute	2003 *n* = 71	2004 *n* = 143	2005 *n* = 69
	Gender		
Female	61	64	56
Male	39	36	44
	Age		
17-20	50	43	41
21-25	24	34	37
>25	26	22	22
	Race [a]		
African	67	79	71
Asian	11	7	10
Coloured	11	5	4
White	11	9	12
	Matriculation Exemption status		
Complete exemption	18	24	58
Conditional exemption	3	15	6
Foreign/mature age exemption	0	3	2
Other (no exemption)	79	58	34
	Matriculation Points		
Less than 24	44	55	22
24-32	40	37	53
Over 32	16	8	25
	School mathematics experience		
Ended in Grade 9	56	55	73
Ended in Grade 10 or 11	3	4	8
Attempted and failed Grade 12	41	41	20
	Type of school attended		
Private school	2	3	3
Poorly resourced school	35	49	46
Adequately resourced school	47	25	21
Ex model C school	16	12	18
Other (unspecified)	0	11	12

Note. All values are percentages based on the data available. Missing data were excluded.
[a] The racial designations are as understood in South Africa

The gender distribution within the three cohorts was more or less constant with about 60% of the preservice teachers in each cycle of the MLE module being female. The percentage of male students in the MLE module, 39% on average over the three years, and up to 44% in 2005, seems disproportionate to the percentage of male students in the Bachelor of Education programme as a whole, but the exact figures were not easily accessible to check. The differential popularity of the FET phase of teacher specialisation along race and gender lines influences the gender distribution, as well as the proportion of African students in the module since this phase is traditionally favoured by male and African students.

Figure 2.4 below shows graphically that the racial composition of the student cohort in the MLE module, although representing all race groups, is largely African. In 2004, the first year of the merged institutions, the cohort was 80% African. Due to the mature age of many students, the racial classification is significant since all, or at least most of, their schooling was in pre-democracy days when they suffered significant disadvantage.

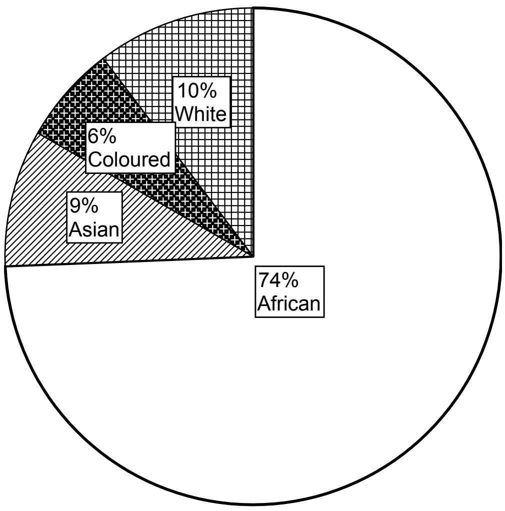


Figure 2.4. Distribution of race groups in MLE module students from all three cohorts

The type of schooling that the students experienced was not divided neatly along racial lines and no assumption was made that race and educational privilege were related. For example, fifteen African students reported attending either a private school or an ex-Model C school. The type of school which the students attended was self-reported (see Chapter 4) and so judgements on, for example, whether their school would count as adequately resourced rested with the preservice teacher. Figure 2.5 shows that overall somewhat less than half (45%) of the students who responded indicated that their schools were poorly resourced, but disaggregating the data revealed that 56% of African students indicated that their schools were poorly resourced.

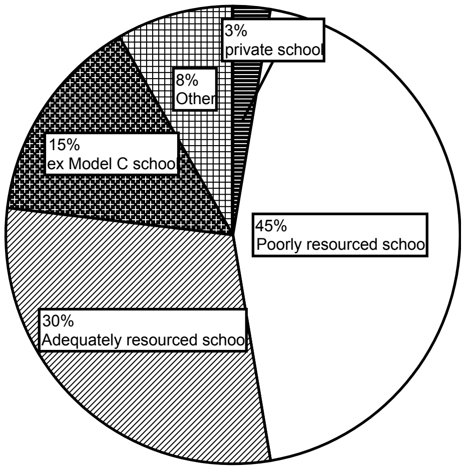


Figure 2.5. Distribution of types of school attended by MLE module students from all three cohorts

The option to continue with mathematics to Grade 12 should be available to learners in all types of schools. The preservice teachers in the MLE module either discontinued mathematics at Grade 9, elected to continue past Grade 9 but discontinued before Grade 12, or persevered to the end of Grade 12 and then failed the final examination. Clearly, members of each of these groupings would be expected to bring different mathematical knowledge and skills to the module and so it was important to be aware of the mathematics schooling of the students. This is displayed graphically in Figure 2.6.

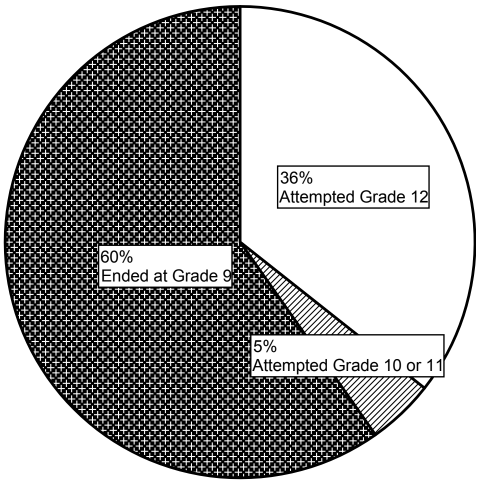


Figure 2.6. Distribution of school mathematics experience of MLE module students from all three cohorts

The students who had ended their mathematics study at Grade 9 level had at least a three year gap between the last formal study of mathematics and the beginning of the MLE module, and for the older students this gap could exceed twenty years. This time lapse since last studying mathematics and the mature age of many students (about 25% were over 25, and all were over 18 by the end of the module) placed the study in the field of adult mathematics learning.

The information presented above (see Figures 2.3 to 2.6) has provided an overview of the preservice teachers who participated in this study. On an individual level, van Groenestijn contends that "everybody carries a backpack filled with a mix of real-life experiences and school knowledge and skills, built on a variety of language, mathematical, cultural, social and emotional aspects….These aspects should not be seen as loose elements but as an entity. They can be distinguished but not separated from each other" (cited in Kaye, 2002, Mieke van Groenestijn section, para. 3).

2.4.3 Location of the MLE module in the adult learning domain

Perhaps somewhat unusually in the university context, I see my teaching in this module as falling in the domain of adults learning mathematics, an emerging field of study. Within the literature, "the definition of an adult learner is nebulous, and revolves around the student, not the level of mathematics being studied" (Fitzsimons & Godden, 2000, p. 14). The term adult learning is preferred in this context to adult education which has connotations of personal development for the middle classes and basic education for the poor. Walters (2006) contends that adult learning activities in South Africa "could be seen 'everywhere and nowhere' as there is no conceptual clarity or co-ordinating mechanism to help hold them in view at one time. This needs a wide angle lens" (p. 22). For reasons to be advanced below, I am suggesting that such a lens will bring the MLE module into focus.

Walters (2006) contends that "lifelong learning is rooted in two main traditions - one concerned with human resource development for the economy; the other concerned with the promotion of democracy and citizenship in the interests of the majority" (p. 10). She continues to explain adult learning in the South African context in a way that resonates very clearly with the descriptions and purposes of mathematical literacy as discussed earlier in this chapter: "Adult learning is embedded in the political, social, cultural and economic processes of society. Its primary social purposes within a context like South Africa are: to enhance possibilities for people to survive the harsh conditions in which they live; to develop skills for people in the formal and informal sectors for economic purposes and for cultural and political education which encourages people to participate actively in society through cultural organisations, social movements, political parties and trade unions" (Walters, 2006, p.12).

Thus the first reason for locating the MLE module in the adult learning domain is the similarity of the broad goals of mathematical literacy and adult learning, namely personal empowerment and an increased possibility to contribute to their community. The second reason for identifying with the adult learning domain is the personal characteristics of many of the students in the module. From the descriptions of the preservice teachers who registered for the MLE module, it should be apparent that many were not traditional university first year students - namely young single people studying full time, straight out of school with few responsibilities, often living at home and subsidised by parents, and whose primary life goals at this stage revolve around completing a degree. Illinois State University (Who is an adult learner?, 2005) has offered the following definition of what they term lifelong learners: "Adult learners are undergraduate or graduate students that are: lifelong learners who generally are 25 years or older, and/or have additional responsibilities such as career, military, or community, and are seeking a degree or other educational offering (credit or non-credit to enhance their professional and/or personal lives."

Cave, LaMaster and White (1998, Information section, para. 1) adopt what they consider a widely accepted definition of an adult learner, namely "an individual whose major role in life is something other than a full-time student". Apart from the age of the preservice teachers doing the MLE module (approximately a quarter of them each year were over 25), I have no formal data on their home circumstances. However, each year saw the birth of several babies to female students in the module, and informal conversations led me to believe that many students have children and other family responsibilities which would put them into the domain of adult learners.

The third, and perhaps the most compelling argument for this classification lies in the "returning to mathematics" and "second chance" dimensions of the MLE module. Internationally, for example in UK, Australia and the U.S, a shift has begun towards older university students whose presence and differing learning styles and circumstances are now being noted (O'Donoghue, 2000). In South Africa, there have been moves by national government to increase access to universities and the increased financial aid packages available have attracted more mature students who previously saw no possibility of tertiary education. In this context, the students doing the MLE module were returning to the basic mathematical ideas that they had left behind years before, and it was, in a way a second chance to succeed in mathematics. Although the area is often termed Adults and Lifelong Learning, see for example Topic Study Group 6 at ICMI 10, which officially includes mature learners of mathematics at all levels, a look at the topics presented makes it clear that the focus is very much on returnees and second chance learners, i.e. those who had had limited success at school level mathematics. I found the adult mathematics education literature particularly helpful in understanding the challenges and complexity of the teaching in this module. For example, Wedege (2002) observes that "many adults who start on vocational education are surprised that the programme includes teaching in mathematics" (p. 72) and many of the students in the MLE module were indeed surprised and extremely disconcerted to meet mathematics on their paths to becoming secondary level teachers of non-mathematical subjects. The literature from the adults learning mathematics domain was also very relevant in the identification of pedagogic practices to motivate the learning of mathematical literacy in the MLE module. This is discussed further in Chapter 3.

2.5 SUMMARY

As illustrated in Figure 2.1, this chapter has narrowed the focus of the study from the broad international debates on mathematical literacy, down to the South African context, then to the institutional context and finally to the Mathematical Literacy for Educators module within the Bachelor of Education programme. An argument was made for situating the module within the domain of adults learning mathematics. The biographical details of the preservice teachers enrolled over the three years of the module were described to provide the reader with a rich context for this study. The detailed description of the broad and specific context of this study, essentially a case study of a particular group of preservice teachers, will allow the readers to judge whether the findings that follow are generalisable to contexts known to them.

CHAPTER 3

LEARNING MATHEMATICS

Mathematics learning cannot be meaningfully discussed without first discussing learning in general. Consequently, at the outset of this chapter, six conceptions of learning are described and contextualised within the field of mathematical literacy, followed by an account of constructivism as a theory of how people learn. Mathematical proficiency, as outlined in the seminal report, Adding it Up: Helping Children Learn Mathematics (Kilpatrick, Swafford, & Findell, 2001), is described, followed by a discussion of how this construct could apply to preservice teachers developing mathematical literacy. One of the aspects of mathematical proficiency is the disposition towards the subject; the result, in part, of a person's mathematical history. The phenomenon of mathematics autobiographies and their role in teaching and learning mathematics is explained. Features of mathematics autobiographies, notably barriers to learning such as affective and environmental factors, and language difficulties are then discussed, drawing both on the literature reporting studies employing mathematical autobiographies as a research instrument, and the more general literature. The chapter continues with a discussion of barriers and enablers to achieving mathematical proficiency in the context of the MLE module, with reference to factors such as language, affect and the learning environment. Finally, five principles for motivating adults to learn are discussed.

3.1 THEORIES OF TEACHING AND LEARNING MATHEMATICS

3.1.1 Conceptions of learning

The meanings that learners themselves attach to learning are important in the context of mathematical literacy which seeks to empower people to operate in the world as citizens, workers and consumers. Firstly, the six conceptions of learning identified by Marton, Dall'Alba and Beaty (1993) are explained, and secondly these conceptions are related to the ideas of learning in the context of mathematical literacy.

Six conceptions of learning

Building on the earlier work of S•lj★, Marton et al. (1993), confirmed the five conceptions of learning previously identified and added to these a sixth conception. The participants in their study were university students engaged in a foundational module designed to foster critical thinking and a questioning attitude to social problems. Data collection was by means of interviews. It was found that learning was understood by the participants in six qualitatively different ways, namely (a) increasing one's knowledge, (b) memorizing and reproducing, (c) applying, (d) understanding, (e) seeing something in a different way, and (f) changing as a person. "Common to all conceptions of learning is the temporal dimension and the idea of permanence. You learn something - it stays - you use it" (Marton, Dall'Alba, & Beaty, 1993, p. 285). In other words, there is an acquisition phase, a time lapse, and then an application phase. Conceptions (a) and (d) are focussed more on the acquisition phase, (c), (d) and (e) on the application phase and (b) combines both phases. The last three conceptions are to do with the sense-making aspect of learning and particularly with (e) and (f) involve generalised capabilities more than specific knowledge acquisition. The description offered by Marton et al. (1993) of the "changing as a person" conception shows how these conceptions are linked: "by developing insights into - or a view of - the phenomena dealt with in the learning material, one develops a new way of seeing those phenomena, and seeing the world differently means that you change as a person" (p. 292). Although Marton et al. (1993) claim that they "do not believe that coming to an understanding of learning as being able to see things in certain ways or as becoming a different person are typical at all" (p. 299), I consider that this conception is an important feature of mathematical literacy learning and if people contend that they have changed as a person, this could be an important indicator of successful learning in this domain.

Interpretation of the conceptions in the context of mathematical literacy

A commonality in the definitions and explanations of mathematical literacy both as a personal competence and a subject to study, is the application of mathematical knowledge and understanding to matters of relevance to the person, who is consequently able to operate more powerfully in the world. In other words, learning in the mathematical literacy domain would transcend the acquisition phase conceptions (increasing ones knowledge and understanding), and be more strongly linked to the application phase conceptions (memorising and reproducing and applying). The consequence of having basic mathematical knowledge and understanding, and being able to apply it as appropriate, provides a mathematical lens through which to view the world and so new insights are possible. Marton et al. (1993) contend that the conceptualisation of changing as a person "does not necessarily mean having the power to control what will happen, but the very understanding of how things are related to each other gives a feeling of being in charge" (p.

293). Such personal empowerment is a key feature of mathematical literacy and furthers a person's ability to take up their role as a self-managing person, a contributing worker and a responsible citizen.

3.1.2 Constructivism as a theory of learning

Constructivism, a philosophical perspective on knowledge and learning, is internationally recognised as a theory which has much to offer to mathematics education (Jaworski, 1994). In her overview of epistemologies of mathematics and mathematics education, Coben (2003) concludes that "constructivist epistemologies of mathematics education view mathematics as a process rather than a product, whereby knowledge of mathematics is gained by doing mathematics. Constructivist educators focus on ways in which the individual learners makes sense of mathematics (after Piaget) or, increasingly, see learning as an activity in which shared mathematical meanings are constructed socially (after Vygotsky)" (p. 27). In the same way as cultures construct knowledge, individuals are not given knowledge but construct it themselves. Learning is seen more as the continuous act of making sense and fitting into experience rather than the absorption of preordained mathematical knowledge, so consequently teaching is the provision of opportunity to make sense rather transferring knowledge (Benn, 1997).

Wilson and Lowry (2000) provide a plan for constructivist learning: "We need to organise learning environments and activities that include opportunities for acquiring basic skills, knowledge, and conceptual understanding, not as isolated dimensions of intellectual activity, but as contributions to students' development of strong identities as individual learners and as more effective participants in the meaningful social practices of their learning communities in school and elsewhere in their lives" (p. 82). Two aspects of learning are evident; the development of individual competence by personal interpretation of the world and life experiences, and further conceptual growth and development coming from negotiation of meaning, sharing of multiple perspectives and the changing of internal representations through collaborative learning. Consequently, three core principles for organising learning seem appropriate: (a) provide access to rich sources of the new knowledge or ideas, (b) encourage meaningful interaction with the content, and (c) bring people together to challenge, support, or respond to each other (Wilson & Lowry, 2000). This description of constructivism seems to go beyond a personal learning theory to include situated theories of learning. These two perspectives, constructivism as developing mind, and situated learning as developing participation, although distinct are not regarded as incompatible (Brodie, 2005; Sfard, 1998). Sfard (1998) suggested the metaphor of acquisition to capture the essence of the constructivist perspective, and the metaphor of participation to capture the essence of the situative perspective. She argues persuasively on the dangers of choosing only one perspective, claiming that "each has something to offer that the other cannot provide" (p. 10). Brodie (2005) supports this view, arguing that cognitive and situative perspectives can be synthesised both "to provide more robust theories of learning, and to bring theory and practice into better relation with each other" (p. 177). The framework suggested by Wilson and Lowry (2000), which includes both perspectives, was considered helpful in describing the learning behaviours in the MLE module. In this study, the term "learning behaviour" denotes the underlying meanings of the behaviour rather than the actual behaviour per se.

Coben (2003) reports that both the individual construct position in constructivism and the other main constructivist approach "which sees the learning of mathematics as happening through social interactions, emphasises the role of context in the process of learning facts, concepts, principles and skills" (p. 27) are well represented in the literature on adults learning mathematics. The styles of teaching and learning that take account of the constructivist theory of learning are, in my view, particularly suited to the content and spirit of mathematical literacy and provide a framework to understand the learning in the MLE module.

3.2 MATHEMATICAL PROFICIENCY

The U.S. National Academy of Science was asked in 1998, by the National Science Foundation and the U.S. Department of Education to undertake a study of mathematics learning. The mandate given to the resultant Mathematics Learning Study was to synthesize the research on pre-kindergarten through eighth grade mathematics learning and to make recommendations for best practice in these initial years of schooling. An important by-product was the introduction of the notion of mathematical proficiency as a description of what successful mathematics learning means. The report of the committee was released as a book in 2001 (Kilpatrick, Swafford, & Findell, 2001), in which a call was made for a concerted effort to develop mathematical proficiency in all students, across divides of class, socio - economic status and race. "For students to be able to compete in today's and tomorrow's economy, they need to be able to adapt the knowledge they are acquiring. They need to be able to learn new concepts and skills. They need to be able to apply mathematical reasoning to problems. They need to view mathematics as a useful tool that must be constantly sharpened. In short, they need to be mathematically proficient" (Kilpatrick, 2001, p. 144).

It is interesting to consider the alternative names considered to capture the notion of successful mathematics learning. Kilpatrick, Swafford and Findell (2001, p. 106) list mathematical literacy, numeracy, mastery of mathematics and mathematical competence as possible names, discarded due to limited scope and/or undesirable connotations in the mathematical education discourse in the U.S. The term eventually chosen was mathematical proficiency, described as an elaborated view of mathematical literacy, which was described in terms of five intertwined strands as in a rope. The five strands identified bring together ideas that have been discussed in mathematics education for a long time and by a variety of educationists. "The idea of the strands resonates with lots of previous work in cognitive science and mathematics education" (Kilpatrick, Swafford, & Findell, 2001, p. 118). Although originally conceived to describe mathematics learning in the first eight years of schooling, Kilpatrick et al (2001) contend that these strands provide a framework to describe proficiency in teaching mathematics and also, I suggest, to describe the proficiency status of mathematics students at all levels of study.

3.2.1 The five strands of mathematical proficiency

Mathematical proficiency is conceptualised in terms of five interwoven strands, as illustrated in Figure 3.1, intended to be developed in concert over the first eight years of schooling. These strands are named and described in the following sections.

Conceptual understanding

This is an integrated and functional grasp of mathematical ideas resulting in the ability to see connections between ideas and the big picture of procedures. Students with conceptual understanding know more than isolated facts and methods - they understand why a mathematical idea is important and the kinds of contexts in which it is useful. "A significant indicator of conceptual understanding is being able to represent mathematical situations in different ways and knowing how different representations can be useful for different purposes" (Kilpatrick, Swafford, & Findell, 2001, p. 119).This understanding reduces the amount that has to be learnt because students can see the deeper similarities between superficially unrelated situations.

Procedural Fluency

This comprises knowledge of procedures, when and how to use them appropriately, and skill in performing them flexibly, accurately and efficiently. "Students need to see that procedures can be developed that will solve entire classes of problems, not just individual problems" (Kilpatrick, Swafford, & Findell, 2001, p. 121), in other words, the structure of mathematics is such that similar procedures work in different situations and it is not necessary to develop a new procedure for each novel problem type. Without sufficient procedural fluency, students have trouble deepening their understanding of mathematical ideas or solving mathematics problems since "the attention they devote to working out results they should recall or compute easily prevents them from seeing important relationships" (Kilpatrick, Swafford, & Findell, 2001, p. 122). Goals associated with procedural fluency are accuracy, efficiency (practice is important to develop these) and flexibility. The link with conceptual understanding is clear- it requires great effort to learn procedures that are not understood and whose steps are disconnected.

Strategic Competence

This refers to the ability to understand the key features of a problem, model it mathematically and solve it appropriately. Kilpatrick et al. (2001) remind us that "although in school, students are often presented with clearly specified problems to solve, outside of school they encounter situations in which part of the difficulty is to figure out exactly what the problem is" (p. 124). When faced with a novel non-routine problem situation, students are required to think productively (as opposed to reproductively when simply recalling procedures) in order to understand and solve the problem. An important feature of this strand is the possession of, and the ability to appropriately select, strategies to solve such non-routine problems.

Adaptive reasoning

This is the capacity to think logically about the relationships among concepts and situations, the ability to reason out answers without computation and to justify and explain answers. Research by Alexander, White and Daugherty (cited in Kilpatrick, Swafford, & Findell, 2001) "suggests that students are able to display reasoning ability when three conditions are met: (a) they have a sufficient knowledge base, (b) the task is understandable and motivating, and (c) the context is familiar and comfortable" (p. 130).

Productive Disposition

This is the tendency to see sense in mathematics, to perceive the subject as both useful and worthwhile, and to see oneself as an effective learner and doer of mathematics and to be convinced that steady effort in learning mathematics pays off. In other words, a productive disposition towards mathematics provides the motivation to engage with the mathematics in the first place, and to persevere in the second place.

The illustration in Figure 3.1 does more than show the five strands - the important feature is the strong intertwining that imparts strength to the rope. The analogy makes clear the futility of developing only one or two strands, or failing to make the connections.

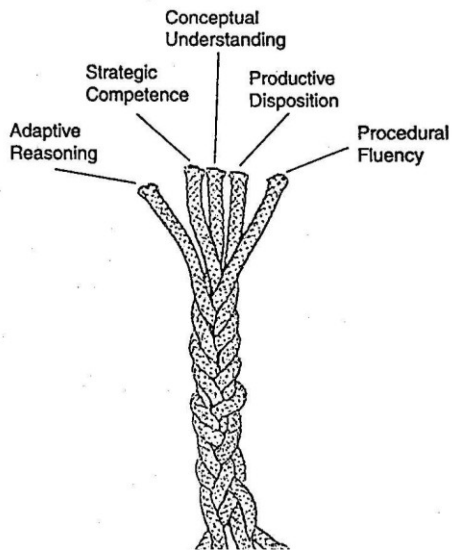


Figure 3.1 Strands of mathematical proficiency (Kilpatrick, 2001 p. 117)

So while it is understood that, in this model, it is not viable to completely separate the strands as they operate in an individual's conceptual schema, it is nevertheless helpful to consider the strength and resilience of each strand in order to understand the overall proficiency of a cohort of learners. Encouraged by the words of Kilpatrick et al (2001), that "because mathematical proficiency has yet to be examined in the way formulated in the report, research should be undertaken on the nature, development, and assessment of mathematical proficiency" (p. 108), in the following sections I will elaborate on the construct of mathematical proficiency, with particular focus on the productive disposition strand, in the context of the MLE module.

3.2.2 Contextualising Mathematical Proficiency in a Preservice Teacher Education Mathematical Literacy Module

In order to provide some context for the following discussion of mathematical proficiency, the intended outcomes of the MLE module, as they were given to the preservice teachers are listed. They were advised that they could expect to:

1. Develop a fresh understanding of the subject mathematics and gain confidence in their ability to work with numbers, shapes and measurements
2. Demonstrate an understanding of numbers (integers, rational and irrational numbers), and an appreciation of the relationships between numbers, and a fluency in working with numbers
3. Use mathematics to investigate and monitor the financial aspects of personal, business, and professional issues.
4. Develop a basic understanding of measurement and scales, and benchmarks for commonly used units.
5. Develop basic statistical literacy, i.e. the ability to work with data, to critically interpret representations of data and to understand the basic ideas of chance. (MLE module outline)

These outcomes straddle the various strands, with the focus more clearly on some strands than others in certain topic areas. For example, the first outcome targets the productive disposition strand, the second the procedural fluency strand, and the third was focused more on adaptive reasoning and strategic competence. Four of the stands of mathematical proficiency are concerned with mathematical content, and those are not the focus of this study, but rather provide the backdrop for the focus on the productive disposition strand. "Mathematical proficiency should be understood as a continuum - it is not an all or nothing attribute and so cannot be characterised as present or absent in a simple fashion. Most mathematical ideas can be understood on many levels and in different ways, and clearly develop over time. However, students should not be thought of as having proficiency when one or more strands are undeveloped" (Kilpatrick, Swafford, & Findell, 2001, p. 135). This means that weakness in any strand is problematic.

Conceptual understanding, Procedural Fluency, Strategic Competence, and Adaptive reasoning in the MLE module

In the context of mathematical literacy, which is concerned more with practical applications than with theories and principles, conceptual understanding has a more pragmatic value than it would in formal mathematics. That said, a very practical value of conceptual understanding is the basis it provides for generating methods of solution of problems and judging the reasonableness of answers. The basic conceptual ideas included in the MLE module were related to fairly basic level mathematics and the intention was that a preservice teacher's integrated and functional grasp of mathematical structures and ideas (i.e. conceptual understanding) would result in an improved level of competence in performing appropriate procedures accurately, flexibly and efficiently (i.e. procedural fluency). The question of what procedure is appropriate is not always trivial and is often obscured when the mathematics is set in real world contexts as would typically be the case in mathematical literacy courses. This requires competence in understanding the key features of a contextualized problem, selecting the correct mathematical model and solving it i.e. strategic competence. Selection of the correct mathematical model and procedure is facilitated when the preservice teachers are able to see the relationship between concepts and reason logically about situations. Insofar as it is possible to do in twelve weeks of lectures, the content of the MLE module was intended to integrate these strands and to help the preservice teachers to strengthen both the individual strands and the meshing of the strands.

The four strands are developed through the module content, and success in the module content as determined by the final module mark (a combination of examination mark, class activities and an independent project) was taken in this research study to signal proficiency to the level required by the module. Achieving mathematical proficiency is not an easy task and requires sustained effort. This effort is most readily offered when the person feels that the end result is worthwhile and that they have a reasonable chance of success, in other words they are positively disposed to achieving mathematically.

Productive Disposition in the MLE module

Folk wisdom tells us that it is not so much what people can do, as what they are willing to do that determines their success. Tobias (1993, p. 100) claims that "negative attitudes…can powerfully inhibit intellect and curiosity and can keep us from learning what is well within our power to understand". In the same vein, Willoughby (2000) at the end of a list of fifteen mathematical skills he believes all people should possess cautions us: "None of the skills above will be of any use if the individual who has learned them has also learned to avoid mathematics whenever possible….If the student has learned to hate mathematics and the learning of mathematics, then I believe the schooling has done more harm than good" (p. 10). From the description of the history and context of the MLE module provided in Chapter Two, it should be evident that the preservice teachers in this module had not, in general, had mathematical experiences that ended well which is likely to have had an adverse effect on their dispositions towards mathematics. Kilpatrick et al. (2001) note that research consistently shows that students' attitudes towards mathematics declines as they proceed through the grades. If the schooling experience is not affirming the initial positive attitudes may turn sour as they come to see themselves as "poor learners, and mathematics as nonsensical, arbitrary, and impossible to learn except by rote memorisation" (p. 132). In the absence of a productive disposition, success in the MLE module would predictably be difficult, and progress in the other strands unlikely to be sustained. While drill and practice type strategies might lead to enhanced procedural fluency, and practice will conceivably help in other strands, the development of a productive disposition from a negative one requires more subtle intervention. Strategies suggested for motivating adult learners are discussed later in this chapter. If the preservice teachers can come to the point where they perceive mathematics as useful and worthwhile, see themselves as effective learners and doers of mathematics, and believe it is worth the effort, they will be empowered to engage with the content of the module and to seek out help where needed. In the best case scenario, they will have the confidence to independently research and learn the mathematics that they need to deal with occasions that might arise in the future.

3.2.3 Constructs related to mathematical proficiency

Having chosen to work with the construct of mathematical proficiency, and in particular the productive disposition strand, it is useful to consider how this fits with other related constructs in the domain of mathematical literacy and the closely related field of statistical literacy. Jordan and Haines (2003) who worked together in the undergraduate programme at Lawrence University, have proposed a three component model for Quantitative Literacy. These three components which "do not stand alone, but work in concert to form quantitative literacy" (p. 16), are (a) foundational statistical and mathematical skills, (b) quantitative reasoning skills, and (c) positive, confident attitudes and beliefs about mathematics and quantitative reasoning. In the elaboration of these components, the connections with the strands of mathematical proficiency are evident. The foundational abilities in mathematics and statistics provide the basis for both the calculations and abstract reasoning required for quantitative literacy. These abilities and skills encompass the conceptual understanding and procedural fluency strands. The adaptive reasoning and strategic competence strands of mathematical proficiency are closely related to the quantitative reasoning skills that are described as the "ability to select, apply, and explain a variety of quantitative methods across different contexts" (Jordan & Haines, 2003, p.16). Finally, the productive disposition strand is synonymous with the attitudes and beliefs aspect of quantitative literacy which is described as more than a positive attitude towards mathematics - including also the disposition to "understand, appreciate, and welcome the need for quantitative methods in answering difficult societal questions" (p. 17).

Gal (2002) proposes a conceptualisation of statistical literacy (arguably a large component of mathematical literacy) and describes its key components as five interrelated knowledge bases (literacy, statistical, mathematical, context and critical) together with a "cluster of supporting dispositions and enabling beliefs" (p. 1). As with the strands of proficiency (Kilpatrick, Swafford, & Findell, 2001) and the components of quantitative literacy (Jordan & Haines, 2003), Gal (2002) cautions that "the components and elements in the proposed model should not be viewed as fixed and separate entities but as a context-dependent, dynamic set of knowledge and dispositions that together enable statistically literate behaviour" (p. 4). The knowledge bases are quite closely tied to the interpretation of data in context and are not easily put in a one to one correspondence with the strands of proficiency. However, the supporting dispositions and enabling beliefs correspond closely with the productive disposition strand. The term dispositions is used by Gal (2002) as an "aggregate label for three distinct but related concepts, critical stance, beliefs, and attitudes, which are all essential for statistical literacy" (p. 18). The first of these is related to the propensity to adopt a questioning attitude to statistical information, and the second and third concern the positive view that individuals hold of themselves as statistical reasoners, and a conviction that statistical processes can be used to reach valid and better conclusions than anecdotal data.

The importance of affective issues in the domain of mathematical literacy is well stated in a document on assessing mathematical literacy in the PISA study: "Mathematics related attitudes and emotions such as self-confidence, curiosity, feelings of interest and relevance, and the desire to do or understand things, are not components of the definition of mathematical literacy but nevertheless are important contributors to it. In principle it is possible to possess mathematical literacy without possessing such attitudes and emotions. In practice, however, it is not likely that such literacy is going to be exerted and put into practice by someone who does not have some degree of self-confidence, curiosity, feelings of interest and relevance, and the desire to do or understand things that contain mathematical components. The importance of these attitudes and emotions as correlates of mathematical literacy is recognized" (OECD, 2006, p. 73).

3.2.4 Summary

Mathematical proficiency, a construct initially suggested to explain successful learning in the first eight years of schooling, has been co-opted to provide a way of understanding the mathematical learning within a mathematical literacy module in a preservice teacher education programme. I have chosen to focus on the productive disposition strand since I believe that that is a very significant determining factor in mathematical success. Other frameworks have similarities, the most striking being the inclusion in each of a dispositional aspect. Since a person's disposition towards mathematics evolves through their school years, consideration of mathematics life histories is an important means to understanding the feelings people have developed towards mathematics.

3.3 MATHEMATICS LIFE HISTORIES

The investigation of mathematics life stories has its roots in the larger research methodology of life history research. "Life historians examine how individuals talk about and story their experiences and perceptions of the social contexts they inhabit" (Goodson & Sikes, 2001, p. 1). Typically, informants tell their entire life stories to researchers in interview situations, and these informal stories are transformed into life histories set into the contexts of place and time by the life historian. The part of the life story of pertinence here, is that pertaining to mathematics - termed mathematical autobiographies.

Mathematical autobiographies (or mathematical life stories) are the personal recollections of a person about their experiences with mathematics as far back as they can recall. Countryman claims that "everyone has a mathematics autobiography. Students bring to class a long history of doing math in and out of school, as well as a set of ideas about the nature of math and their own ability to do and understand it" (1993, p. 52). "In mathematical autobiographical work, attention is focused on one's personal mathematics history and the forces and contexts that have patterned they way we see and do mathematics" (Benn, 1997, p. 107). Mathematical autobiographies are typically elicited by personal writing or interviews that describe the mathematical progression through school and into work. Benn (1997) however, consequent to her work with adult learners, cautions that linear autobiographies possibly reflect a white male experience more than other societal groupings. For example, many women, especially from minority groups, experienced breaks in their education for child rearing and they might find it more appropriate to express their mathematical autobiographies as a collage or montage. There is a strong precedent for using mathematical autobiographies in educational research.

Repsold (2002) describes her classroom practice of getting students at school level to write autobiographies as the initial task in a year long journal writing project. Countryman, (1993), also includes autobiographies in a range of activities designed to use writing as a tool to learn mathematics. Ellsworth and Buss (Ellsworth & Buss, 2000) have used autobiographical writing of mathematics (or science) histories with preservice elementary school teachers; Hauk (2005), used mathematical autobiographies with students in college level service mathematics courses (for example, prospective elementary mathematics teachers) in order to see whether this expressive writing tool would activate reflection in any useful way; and Coben (2000) used mathematical autobiographies of college level students as part of a larger project of life history research. Gibson and Costello (2000) asked Art and Design students to write about an experience in mathematics class at school which made an impact on them in order to assess their feelings about mathematics. The use of mathematical autobiographies is widely, but not exclusively, cited in the context of mathematics anxiety, (see for example Benn, 1997; Tobias, 1993). Moody's study (2003) used this method to understand the mathematical histories of successful African American woman students, and to gain insight into their perceptions of their experiences with maths and maths teachers. The benefits of using mathematical autobiographies, as put forward by these researchers will be discussed along with their caveats and methods of data collection.

3.3.1 Mathematics autobiographies as aids to self-knowledge

I concur with Benn (1997) that the exercise of writing a mathematical autobiography is a way of "allowing the learners a way of contextualising their learning and experience of mathematics within a social framework. By telling their own story, learners can explore the construction of their mathematical knowledge and how experience has shaped this" (p. 107). This view is supported by Ellsworth and Buss (2000) who determined that "through the autobiographical writing process, education students can see the influences and experiences that affected their view at different points in time" (p. 356). In general then, writers of the autobiographies are compelled to reflect on the path they have travelled to arrive where they are in terms of their mathematics learning. In particular, the following four forms of self-knowledge can be surfaced:

Self-knowledge about learning style.

Writing about the successes and disappointments they have experienced in their mathematics learning helps students to reflect on how they learn, and to pinpoint the nature of the difficulty they experienced. Repsold (2002) regards "helping students to become life-long learners as a key goal and along with this comes a responsibility to get students to understand how they learn" (p. 44). Self - knowledge of learning styles that have proved successful (or unsuccessful) in the past, provides the student promising strategies for future learning.

Self-knowledge about personal accountability.

Repsold (2002) reports that, on reflection, students often admit that it was their lack of work that led to poor results. This admission can "help students to take responsibility for their own actions and recognise that actions have consequences" (p. 44). Furthermore, "writing enables many students to take more responsibility for what goes on in class, for as they write about doing mathematics, they come to see themselves as central to the process of learning" (Countryman, 1993, p. 52). Taking ownership of, and responsibility for, their own mathematical learning is an important step towards success as life-long mathematical learners.

Self-knowledge of the social nature of learning mathematics.

In addition to their own role in shaping their mathematical history, as they write students can realise that the behaviour of others has affected their education, and likewise perhaps their own behaviour has affected others (Repsold, 2002). Class discussions of mathematical autobiographies can help students to see themselves as part of a community of mathematics learners with many peers who have shared similar experiences to them (Countryman, 1993).

Self-knowledge of potential to succeed.

Although a student's story might be generally of struggle, there is always the possibility that students can look back and see the connections they have made in particular areas, and hopefully feel more positive about their ability to succeed in maths (Repsold, 2002). This is made more likely if there is a specific request to include some highlights of their mathematics learning.

3.3.2 Mathematics autobiographies as aids for teaching

When class size is large, Countrymans's view (1993) that "reading math histories also helps teachers see their students as individual learners with passions, needs, and beliefs about knowledge and themselves" (p. 52), becomes very important. She advises that teachers scan the autobiographies when they are first written and then reread them carefully a few weeks into the course, and make appropriate personalised comments.

The information gleaned from the mathematical autobiographies is valuable in both creating and maintaining classroom environments conducive for mathematics learning, and in designing instructional activities. For example, following his study of mathematically successful woman African American students, Moody (2003) advises us that "listening to their stories has the potential to create useful discourse among mathematics educators about specific teaching practices and classroom environments that help foster successful

African American mathematics students" (p. 33), and that the autobiographies create "starting points for discussions of classroom practices and teachers that work to propel African American students into Mathematics" (p. 37). Repsold (2002) concurs that autobiographies can provide insight into the race and gender impressions surrounding mathematics.

"Autobiographies are an effective tool for assessing students' predispositions toward content areas" (Ellsworth & Buss, 2000, p. 55) and can provide the teacher with some sense of the struggles experienced by the learners in the past. For example, Tobias (1993) noted that "mathematics autobiographies show that, for the beginning student, the language of mathematics is full of ambiguity" (p. 54). Teachers who are reflective about their practice should take note of the stories, especially common threads since, as Ellsworth and Buss remind us, (2000), "thinking about what we do in the light of what we know from research and daily experience helps us distinguish between what is important and what is simply habit" (p. 362). Very often, teachers do not realise the influence they exert on the learning of the students, and reading the autobiographies can alert them to this.

In the following section, the role of language, affect and environmental factors as barriers and/or enablers for mathematics learning are discussed. Where applicable, the related themes identified by researchers in student mathematics autobiographies are discussed together with the insights from the general literature.

3.4 ACHIEVING MATHEMATICAL PROFICIENCY: BARRIERS AND ENABLERS

The many barriers in the way of people achieving mathematical proficiency are documented in the literature and self-reported in their own mathematical autobiographies, along with descriptions of enablers such as helpful teachers, supportive family members and particular motivational and learning strategies. Barriers include language, affective factors such as beliefs about the nature of mathematics, attitudes of confidence and self-efficacy and mathematics anxiety, and a host of environmental factors such as schooling, family or community problems. Enabling factors for achieving proficiency include the employment of motivational strategies specifically suggested for adult learning, and teachers sensitive to the particular issues of adult learning. Since my particular interest was to derive a framework for the analysis of the mathematical autobiographies, a good deal of the literature consulted dealt with the barriers identified from similar studies and this is integrated here with the general literature. The data analysis framework derived from this discussion of the literature is presented in section 4.6.4 where my use of mathematical autobiography as a research instrument is described.

3.4.1 Language as a factor in achieving mathematical proficiency

In South Africa, the issue of language in education has always been extremely politicised and hotly contested (Setati, 2005, p. 103). Mda (2004) recognises "language as key to learning, and language rights as key to fundamental human rights" (p. 177). In her overview of the changes in language policy and use in education in the first ten years of democracy in South Africa, Mda concludes that despite the introduction of new language policies to redress past imbalances, "the status and use of African languages in education has not improved greatly" (p. 177). Setati agrees that "although it is the main language of a minority of the population of South Africa, English is both the language of power and the language of educational and socio-economic advancement" (p. 75). We thus have the situation in South Africa, where the vast majority of learners at school level are still acquiring English whilst in the midst of English language instruction in all subjects. Many African learners, especially in rural schools, have still not acquired adequate English proficiency by the end of their schooling, and so they carry language difficulties into their tertiary education. This creates a language barrier to learning mathematics that will be discussed in terms of four aspects: (a) poorly developed reading skills (especially in English, the language of instruction) which limit understanding of print-based material, (b) the schooling legacy of many learners in which an African language or limited English was used to explain mathematical concepts which are subsequently assessed in English (c) the issues of dealing with mathematical and statistical language, and (d) the issue of the language of instruction at the university not being the home language of many learners.

Reading

Bohlman and Pretorius (2002), reporting on their research among students in a Mathematics Access module at the University of South Africa, claim a robust relationship between reading ability and academic performance in mathematics. Their results suggest that "while high reading scores do not guarantee mathematical success, a low reading score does limit mathematical achievement. In other words, poor reading ability…seems to function as a barrier to effective mathematical performance" (Bohlman & Pretorius, 2002, p. 201). The weak readers in their study (all university students) achieved reading comprehension levels of 50% or less, meaning in effect that they fail to properly understand half of what they read. Informal talks with language specialists indicate that the frustration level is 70% comprehension - in other words readers who fail to understand 70% of the text are found to abandon the task. The context rich dimension of mathematical literacy is correspondingly language rich. Real life problems such as choosing a suitable medical aid package, are typically embedded in copious text containing conditional statements and low frequency words probably unfamiliar to weak readers. The chances of poor readers missing the point of the problem are high, and this lack of comprehension will adversely affect their mathematical performance.

The issue of bilingual classrooms at school level

The language problems of adults in South Africa have their roots in the schooling system and so the issues identified at school level are relevant to this study. After extensive analysis of the South African dataset arising from the Third International Mathematics and Science Study - Repeat (TIMSS_R), Howie (2002) presented twenty five key findings, some of which relate to issues of language. The third key finding was: "Pupils who spoke either English or Afrikaans at home achieved higher scores than those who did not" (p. 258). Given that the language of learning and teaching for the pupils tested would have been, according to South African government policy, either English or Afrikaans, this finding can be understood as indicating that those whose schooling was in their home language did better on the mathematics tests than those pupils whose schooling was in their second language. Setati (2005) concedes that the statistics indicate this but cautions that the explanation is more complex than the fact that learners are taught and assessed in their second language. "The major disadvantage is not that they are not fluent in the language of learning and teaching, but it is the in the fact that learning mathematics in their main language would create opportunities for them to engage in a range of mathematical discourses and thereby be better prepared to respond to questions such as those contained in the TIMSS, which require fluency in a range of mathematical discourses" (Setati, 2005, p. 103). The USA has a significant number of students acquiring English in the urban schooling system, mainly from Spanish speaking families. In this context, Secada (1996) observes that research and evaluation involving bilingual education programmes in general "have taken for granted the school mathematics curriculum that students are exposed to and, even when problems in instruction are noted, those concerns get cast in terms of language development" (p. 435). In other words, we are warned against automatically ascribing poor achievement in mathematics to language difficulties without a critical examination of the possible deficits in the teaching and learning strategies employed. In support of this caution, it must be noted that several other countries participating in the TIMSS-R study also had relatively large numbers of second language pupils and yet they performed as well as the first language pupils in their own country and better than the top performing pupils in South Africa (Howie, 2002), indicating that there could be other factors at play. However, "the results show that if the minimum language proficiency is missing then pupils cannot gain access to the maths easily" (Howie, 2002, p. 254).

Mathematical and statistical language

Tobias (1993) contends that the everyday connotations of words interfere with the mathematics meaning and "when people already feel insecure about math, linguistic confusion increases the sense of being out of control" (p. 59). Perceptive students often perceive ambiguity and become frustrated when teachers are unable or unwilling to explain differences in meaning between, for example, circles and discs.

McLean (2002) identifies the issue of vocabulary as an obstacle to learning statistics since the development of concepts is intimately linked with the vocabulary used for them and furthermore most of the simple statistical vocabulary uses everyday words, but usually with more specialised meanings. In the same vein, Rangecroft (2002) speaks of the complexity of dealing with words which have different meanings in Ordinary English (OE), Mathematical English (ME) and Statistical English (SE). For example, the word *range* in OE could refer to a lot of mountains or a collection of the new season's fashion, in ME the range is a set of values that the y values in a function may assume, and in SE the range is the difference between highest and lowest scores and so is a single number. To add to the confusion, there are quaint terms in basic statistics that describe the shape of the graphical representation of data, for example, "box and whisker" and "stem and leaf" plots. Students have been reported to have drawn pictures of actual leaves and stems where a statistical plot was required, and to have misheard "box and whisper", or even "box and whisky" which must have been rather baffling (S. Hobden, 2004). Most mathematics classes are conducted in a mixture of OE and ME and it is important that learners are able to distinguish between the two. "In an English-medium classroom of multilingual learners who do not speak English as a first language, the confusion between OE and ME is complicated by the fact that both languages (OE and ME) are new to the learners" (Setati, 2005, p. 81).

The vocabulary aspect discussed above is part of the mathematics register which can be thought of as the vocabulary and phrases, symbolic notations, and ways of speaking (and writing) whose appropriate use can mark someone as knowing mathematics (Secada, 1996, p. 443). An argument can be made that the reasons students acquiring English do not achieve as well in mathematics as their English-proficient peers is that they lack knowledge of the mathematics register. Secada (1996) notes however, that "there is no evidence that English -proficient students have any better grasp of that same register" (p. 433). Mathematical symbols and language often seem arbitrary which makes the subject seem inaccessible. Kettler (2002) coined the phrase "symbol-shock" to capture the phenomenon of students appearing to take fright when confronted with mathematical symbols, and their subsequent emotional block to engaging with the work. She reminds us that the first mathematical symbols (for operations) are encountered in the early years and so some learners may have suffered symbol shock for years and learned to handle it by a behaviour pattern she terms "manipulation according to the same old way" (p. 2). Rather than trying to understand the symbols in the particular context, they plunge into a mechanical procedure that might superficially comply with the symbol. I consider this an aspect of language difficulty and unfamiliarity with the mathematics register.

Language of instruction at tertiary institutions

Language problems seem to follow learners into their tertiary studies. Following his work at Vista University, a South African tertiary institution, De Wet (1998) identified two language related problems amongst what he terms historically disadvantaged students. These were difficulties with standard English compounded with the problem of explaining abstract statistical concepts, and difficulty in understanding the examples in the statistics textbooks which were mostly related to first world situations.

In a later study involving English second language speakers, the language ability of South African first year tertiary students studying basic statistics was tested by means of a test to determine if students understood what Nolan (2002) considered specific statistical terms. The eight terms chosen (at least, at most, sketch, construct, name, describe, calculate, estimate, average) are in my view common to mathematics generally. They were tested in the context of problems, where we can presume the researcher felt that incorrect answers were the result of language difficulties and not deficits in other areas such as conceptual understanding. According to this study, the students did not perceive their understanding of English formulations and explanations in the text book to be a problem despite the general perception of researchers of low levels of English Second language proficiency. Coetzee - Van Rooy and Verhoef (cited in Nolan, 2002, p. 4) offer as an explanation the possibility that when the respondents evaluate their proficiency in English, they might have its role as lingua franca uppermost in their minds, but not its role as a medium of instruction that requires academic language proficiency.

By and large, tertiary institutions in South Africa are racially mixed and so a learner used to classes where all the learners and the teacher speak the same African language, and code switching is prevalent, could experience difficulty. Code switching is a practice whereby two or more linguistic varieties are used within the same conversation. In classroom situations, this might, for example, occur when a teacher initially explains a concept in English, and then re-explains it in isiZulu, or breaks off the explanation in English to reprimand a learner in isiZulu, or when one learner might repeat the teacher's explanation to a peer in their home language. Apart from the last example, this is unlikely to occur in a large tertiary institution, and while the merits of code switching are cause for debate (see Setati, 2005), its absence could put pressure on students.

3.4.2 Affect, Mathematical anxiety and personal factors as factors in achieving mathematical proficiency

Affect can be seen to comprise beliefs, attitudes, and emotions; these three areas are ranked in order of increasing intensity and decreasing stability (Evans, 2000). Evans (2000) reports "a substantial measure of agreement about the affective variables that might be expected to influence thinking and performance in mathematics in older students and adults" (p. 44). These are:

1. mathematics anxiety
2. confidence, with the associated ideas of self-efficacy and locus of control
3. perceived usefulness of mathematics
4. perceived difficulty of mathematics
5. finding mathematics interesting and/or enjoyable

I have chosen to conflate the variables (3), (4) and (5) above and discuss them under the umbrella heading of beliefs about the nature of mathematics. The attitude aspect of affect is covered by a discussion of confidence, self efficacy and locus of control, and finally the emotional response to mathematics, mathematics anxiety is discussed. Before the discussion of affective factors though, it is prudent to consider that the difficulty people have with mathematics may be physiological, and hence a brief overview of dyscalculia as a possible barrier to achieving mathematical proficiency is provided.

Dyscalculia

Colwell (2003) reports that neurologists and psychologists are making progress in mapping areas of the brain which are associated with various mathematical activities, typically in medical studies dealing with loss or absence of functions such as number recognition, comparison of number size and simple arithmetic. Such scientific studies seem to lie outside the sphere of educational interest but Colwell advises that "the knowledge of cognition being developed should have important implications for the improvement of teaching and learning, both for students with learning difficulties and disabilities and more generally" (p. 105). Perhaps there is some substance to the general notion of a "maths brain" - a notion often used by people to explain ability in mathematics.

Dyscalculia has been defined in various ways but the following aspects seem to be agreed: (a) the presence of difficulties in mathematics, (b) some degree of specificity to these (i.e. the lack of across-the-board academic difficulties) and (c) the assumption that these are caused in some way by brain dysfunction. Of particular interest in this study is developmental dyscalculia (as opposed to acquired dyscalculia which manifests after injury or disease of the brain), which is thought be have a prevalence of between 3% and 6% of the population (Colwell, 2003), which is a similar prevalence to developmental dyslexia and attention deficit hyperactivity disorder. Symptoms vary but include difficulties with number recognition and size, poor ability to memorise number facts, poor judgement of measurement and poor ability to perceive spatial relationships (Colwell, 2003).

If the frequency of developmental dyscalculia is as high as 6% of the population, Colwell (2003) points out that there could be significant numbers of adult learners with genetic impairments that affect their abilities to learn mathematics. Diagnosis of dyscalculia in adults is complicated by the realisation that mathematics tests "reveal what adults have and have not been able to learn, but not necessarily whether they have specific learning difficulties" (Colwell, 2003, p. 109).

Beliefs about the nature of mathematics

The perception people have that mathematics is a difficult, abstract and irrelevant subject negatively effects their disposition towards the subject and consequently, in many cases, their success. This view is supported in the literature, for example, Rosnick (1981) contends that the "inherent difficulty of the subject mathematics itself" (p. 418) is a reason to be added to the cultural, political and psychological factors that are often used to explain why so many students have difficulty with, and an aversion to mathematics. This difficulty is, in part, due to the increasing abstraction of mathematics from elementary to senior school with the accompanying use of increasingly obscure symbols. "For many students…unfamiliarity with mathematical symbols and the abstract concepts to which they refer breeds contempt for mathematics" (Rosnick, 1981, p. 418). This is clearly related to the language barrier discussed previously. Coben (2003) cites a research review on the attitude of adults to mathematics in which it was found that "abstraction and lack of relevance in mathematics is a common cause cited by students for their dislike of and failure in mathematics" (p. 92). The focus on the abstract nature of mathematics tends to lead people to devalue the everyday mathematics that they regularly use successfully. Coben (2000) uses the term "invisible mathematics" to mean the mathematics which one can do, but does not recognise as mathematics. This occurs in autobiographies when people dismiss the everyday mathematics they do successfully (such as budgeting or measuring) as mere common sense, and insist that they are poor at mathematics because they cannot do the standard school mathematics. Fitzsimons et al. (2003) observe that in the case of mathematics education "it is clear that, internationally, traditional methods of curriculum development and teaching have failed large numbers of people who have been alienated by its abstract, decontextualised content, and are likely to have formed beliefs about their own ability in this subject" (p. 107). Poiani (1981 p. 157), among five reasons suggested for math anxiety and avoidance, includes the many choices that are required in school mathematics. He claims that decision making is stressful in almost all circumstances and especially in mathematics when "choosing the right procedure from all those learned is a non-trivial, anxiety producing task" (p. 157). This is often mentioned in autobiographies as writers recall that, for example, they could never decide on which formula to use, or which procedure was appropriate. Added to the pressure, is an emphasis on coming to the correct answer quickly which causes panic. This search for the single correct answer evolves into a search for the right formula or rule as the learner moves through school. If the correct formula is not apparent, learners assume they are missing some vital knowledge and stop trying (Tobias, 1993).

Just as the conviction that mathematics will be useful for future career opportunities is a motivating force to learn mathematics, a belief that mathematics is irrelevant to their life acts as a demotivating influence, which can be considered a barrier to successful mathematics learning. Mathematics can be considered useful in two ways: it is useful as a ticket into higher education or employment, and it is useful for use in daily life. Coben (2000) identified a theme in mathematics autobiographies that she named the "door". This referred to a door marked Mathematics that blocks the way to a chosen path of study or job and reflects the use of maths as a gatekeeper to training and employment. Ellsworth and Buss (2000) identified a theme they named "relevance" characterised by students describing the value, positive or negative, of mathematics/science in relation to seeing or not seeing its application in real life (p. 359). This theme was identified in more than half the student autobiographies in their study.

Ability, Confidence and self-efficacy beliefs

"There is considerable evidence to support the idea that learners' attitudes, beliefs and feelings about mathematics and their confidence (or lack of it) in their own mathematical abilities have an effect on their learning" (Coben, 2003, p. 92). Many mathematics autobiographies include mention of personal factors effecting their mathematics achievement - these include deficits in ability, effort and confidence.

Lack of ability. Students who write that they do not have a "maths brain" seem to believe in the innate nature of mathematical ability. Tobias (1993) notes that this is a particularly Western notion, since in general Asians attribute high mathematics achievement to hard work but Americans are more likely to attribute high achievement to ability. A consequence of a belief in the innate nature of mathematics ability is a belief that everyone has a limit so when a difficult concept is encountered, people think they have reached their limit and so give up, and attribute the failure to lack of ability. This could possibly also be the reason behind the many instances of students reporting their own lack of effort in learning mathematics in their autobiographies.

Lack of confidence. It is self-evident that confidence, or the self -assurance in ones ability to succeed, is eroded by a history of failure. Unpleasant experiences have often caused students to be fearful of making mistakes and to distrust their own intuition. Anxious students think that if they have the answer in their mind, it is probably wrong. If they cannot recall the formula, they give up whereas more confident students trust their flashes of insight (Tobias, 1993). This lack of confidence is widespread - Duffin & Simpson (2000), for example, speak of "the usual negative self -deprecating remarks made by adults who are successful in many spheres of life, but not maths" (p. 83). In addition to public remarks indicating a lack of confidence in mathematics, Tobias (1993) highlights the issue of self-defeating self talk and adds: "self -talk is what we say to ourselves when we are in trouble. Do we egg ourselves on with encouragement and suggestions? Or do we engage in self-defeating behaviours that only make things worse?" (p. 69).

Poor self-efficacy beliefs. Self-efficacy beliefs, which Bandura (1986) defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 391), strongly influence the choices people make, the effort they expend, how long they persevere in the face of challenge, and the degree of apprehension they bring to the task at hand. What people know, the skills they possess, or the attainments they have previously accomplished are often poor predictors of subsequent attainments because the beliefs that they hold about their abilities powerfully influence the ways in which they will behave. A person develops self –efficacy beliefs based on information they glean from their mastery experiences, either successful or unsuccessful; vicarious experiences, either by observing that others can do it, or that others are generally unsuccessful; the social and verbal persuasions of those around them which may serve to encourage or undermine beliefs of self-competence; or from their general physiological or emotional states (Bandura, 1986). It is easy to see how learners used to failing mathematics in the company of many of their peers, and with little encouragement from their teachers, might develop very poor self-efficacy beliefs. Grayson (2005), contends that poor self-efficacy beliefs "can lead people to justify their inactions or poor performance by blaming someone else- the system, the government, their boss, anyone but themselves" (Negative effects of poor self-efficacy section). The power that individuals ascribe to the factors that influence their mathematics learning differs among individuals. A helpful construct in describing this is the concept of locus of control.

Locus of control. This idea, described below, is perhaps the best known work of psychologist Julian Rotter. "Locus of control refers to people's very general, cross situational beliefs about what determines whether or not they get reinforced in life. People can be classified along a continuum from very internal to very external. People with a strong internal locus of control believe that the responsibility for whether or not they get reinforced lies with themselves. Internals believe that success or failure is due to their own efforts. In contrast, externals believe that the reinforcers in life are controlled by luck, chance and powerful others" (Mearns, 2005, p. 3). In the mathematics education literature, the term external locus of control is used in a pejorative sense, and is seen as disempowering and a barrier to learning. While people with an internal locus of control are much more likely to take control of their lives, environment, and situations, those with an external locus of control tend to perceive action as pointless, and are less likely to make an effort to take control or change things. Writing in the context of mathematics anxiety, but very relevant here, Frankenstein (1983) contends that one of the obstacles to critical mathematics education is math anxiety since "as Freire stresses, people who are not aware of the raison d'être of their situation, fatalistically 'accept' their exploitation" (p. 328). She advocates an examination of how "the structures and hegemonic ideologies of our society result in different groups being more affected than others by this anxiety" and how "to some extent, people participate in their own disempowerment" (Frankenstein, 1983, p. 328). Hauk (2005) found the notion of locus of control a useful basis for her analysis of college student mathematics autobiographies. Students, who through their autobiographies, revealed that they felt responsible for their own mathematics experiences were classified as exhibiting an internal locus of control, whereas those who claimed that their success or failure in accessing and understanding mathematics was due to environmental factors such as teachers, or poor school circumstances were classified as exhibiting an external locus of control. She found that "the notion that mathematical knowledge was something completely external to self pervaded students' writings and interview responses" (p. 42).

Mathematics anxiety

This is, in a sense, a catch-all term that is used to describe a syndrome which is a consequence of some or all the affective factors mentioned above. Tobias (1993), notes that for most people, mathematics is more than a subject – it is a relationship between themselves and a discipline purported to be 'hard' and reserved only for an elite and powerful few. Thus, all people endure some mathematics anxiety, but it disables the less powerful – that is, women and minorities more" (p. 9). She believes that it is anxiety and not lack of ability that prevents many people from reaching their potential in mathematics. This gives hope to people since, while not much can be done about a lack of ability, "you can do a great deal about being fearful" (p. 10).

All the affective factors discussed above, are personal to individuals and represent barriers to learning that are within themselves. There are, in addition, many factors in the schooling and community environment that can influence success in mathematical learning. As is commonly the case, the more marginalised members of the community (women, second language English speakers, the poor) are most disadvantaged.

3.4.3 Environmental factors in the achievement of mathematical proficiency

In the context of this study, the preservice teachers were attending classes in a well resourced university with a dedicated education campus. Many were living in the student residences with adequate private study facilities and easy access to both the library and internet resources and so they were in an enabling environment for their tertiary studies. What follows is mostly a description of the environmental factors that impeded the mathematical progress of many students in their schooling years, and which has clear relevance to their current struggles at tertiary level. The environmental factors that feature in mathematics autobiographies typically include anecdotes of their interactions with other people in a mathematical context, and descriptions of the circumstances in which the interactions occur. Coben (2000) has identified an overarching theme of the "significant other" - someone perceived by people as a major influence on their life history. This influence might be positive or negative, past or present, and often persists for many years after the event. I am dividing the "significant others" into family, teachers and the general community.

Family

In their study with preservice teachers, Ellsworth and Buss (2000) found that the majority of autobiographies mentioned the impact of family members; parents, siblings, spouses and children. Their "data showed that family members' influence carried powerful messages throughout the student's entire learning career" (p. 359). This influence can, for example, take the form of contagion whereby the mathematics anxiety of parents infects the learners (Poiani, 1981), or more positively where students remember parents helping them with their homework.

Teachers:

Ellsworth and Buss (2000) found that a major influence on attitudes of students were the comments (supportive or demeaning) made by teachers to students. This view is supported by Benn (1997) who remarks that many students, often twenty years or more later, recall the negative comments made by their teachers. Preliminary reading of the data in this study revealed many verbatim quotes of what teachers said, as well as descriptions of teachers who are frequently late or absent from school, drunk on duty and general abusive and hostile to children - far more extreme than the stories reported by Gibson and Costello (2000) which "depict teachers as eccentric, unfair or unsympathetic" (p. 38). Students perception of teachers' subject content knowledge was found by Ellsworth and Buss (2000) to be an influence on students' attitudes. More significant perhaps, in students' autobiographies are their memories of the professional (or unprofessional) behaviour of the teachers. Poiani (1981) specifically mentions negative childhood experiences, typically humiliation when the maths is not done quickly or correctly, and punishment for failing to understand (p. 157). Ellsworth and Buss (2000) report that issues of gender were evident in only 13.5% of female autobiographies, but when they did occur, the effect was powerful.

Two perceptions of teachers are typically found in autobiographies: Teacher as authority where the teacher is perceived by students as having the power to determine the student's success or failure and is acknowledged accordingly; and teacher as facilitator where the teacher is perceived by students as helping them to be empowered (Ellsworth & Buss, 2000). The facilitating teacher is similar to what Moody (2003) identifies as a caring teacher, which in his study included more than simply being nice - a caring teacher was a good disciplinarian, well versed in his/her subject and a good teacher who encouraged and motivated the students. In contrast, the authoritarian teacher seemed to the students to have the authority to dictate their success and failure (Ellsworth & Buss, 2000). This relates strongly to the notion of locus of control discussed in section 3.4.2 above.

Classroom practice and curriculum issues in schooling.

The classroom practice and instructional strategies employed by the teacher are important factors in shaping attitudes to mathematics. For many students, primary school mathematics is characterised by drill and practice type activities as teachers tried to develop automaticity in the basic number facts by emphasising skills and memorisation. In their autobiographies, students described direct relationships between proficiency in procedural skills and memorisation, and feelings of success. Students who were successful at speed tests and competitive games recalled them as highlights and good memories while those who struggled to work fast remembered them as critical events where they felt like failures. They remembered a sense of threat, inadequacy and embarrassment because the experiences were so public (Ellsworth & Buss, 2000). The tension between comprehension and coverage was mentioned by over a third of the preservice teachers in the study done by Ellsworth and Buss (2000). They "expressed frustration about moving on too fast and not spending enough time on concepts to gain a comfortable understanding" (p. 359). Students described experiences which reflected feelings about understanding content; either by expressing the desire to spend more time on understanding concepts rather than covering content, or describing instances in which they felt successful because they understood.

When learners struggle with mathematics, they are often treated, for that subject at least, in similar fashion to those with learning disabilities. As Goldman, Basselbring and the Cognition and Technology Group at Vanderbilt (1997) remark: "much of their (students with learning disabilities) instruction focuses largely on procedural computation skills that are executed in similar ways each time they are used" (p. 199). This is not a good platform for the type of critical engagement with mathematics that is the mark of a mathematically literate person.

We are reminded by Benn (1997) that "the role of the education system in constructing individual self identities cannot be underestimated" (p. 106). Furthermore, "study findings demonstrate that students' attitudes are being affected at all levels, from elementary to college, and that the praise or blame for student attitudes cannot be placed at the doorstep of any one level of education" (Ellsworth & Buss, 2000, p. 361). The role of the education system is particularly pertinent in South Africa where historical inequities in educational provision under the apartheid regime affected the majority of school learners.

Schooling in disadvantaged schools in South Africa

The mean age of the preservice teachers involved in this study was 23 years, which means that they began their schooling in the late 1980's, and some of the older students had already finished school by then. This means that all the preservice teachers had done some or all of their schooling under the apartheid regime where schooling was differentiated according to race.

The extremely poor conditions in some African schools is well documented to the extent of the characterisation of students as "historically disadvantaged". For example, consequent to his work at Vista University, a historically disadvantaged institution, De Wet (1998) describes a historically disadvantaged student as "a student who has been deprived of normal quality education during the whole of his/her school career" (p. 573) and continues to describe what I consider a very extreme picture of a student not taught how to study, with unqualified and unwilling teachers in derelict schools, and from very low standards of nutrition and family circumstances. de Wet claims that his institution enrols the lower category of historically disadvantaged students whom he observes "represent very poor university material" (p. 574).

Less subjective evidence is available from the analysis of the TIMSS-R data recently reported (Reddy, 2006b). It is reported that between 40% and 50% of South African learners at Grade 8 level attend schools which their principals and teachers rate as having a low resource base for mathematics teaching and learning, a low school climate, and low school and class attendance (p. xvi). International comparisons indicate that South African class sizes are large, the teachers poorly qualified, and the mathematics achievement is very poor. Most concerning is that the "mathematics score for African schools decreases significantly from TIMSS 1999 to TIMSS 2003" (p. xii).

This bleak picture indicates that the schooling factor, for learners especially in rural schools, is a barrier to their successful mathematics learning. Not surprisingly, there has been "a flight of children out of the former black schools" (Soudien, 2004, p. 89) but this is dependent on their parents or sponsors having the resources to pay the substantially higher school fees. This gives rise to a new consideration, the integration of black learners into schools to which they were previously denied access.

Black learners in traditional well resourced schools

Stiff (1990) contrasts the culture of traditional mathematics classrooms in the USA with the culture of African American students and suggests that the mismatch has a negative effect on their mathematics learning. He contends that the traditional Mathematics classroom culture includes: (a) working independently, (b) being direct and concise, (c) valuing direct and efficient methods of obtaining information, (d) using accepted (elaborate) syntactical discourse, and (d) responding in an orderly and structured manner in classroom situations. In contrast, the African American cultural frame of reference entails attributes that include working in support groups, telling tangential stories that may or may not relate to the problem, valuing the personal relationships that can be nurtured using a "conversational style" discourse and perhaps leaving ones seat to answer a question. The tension that is sure to result from these different cultures sends the message to the African American students: "You are not the type of mathematics student we want" (Stiff, 1990, p. 156). Moody (2003) also reports the strength of prejudice. He cites the example of a good student whose enduring memory of Eighth Grade was what she perceived to be the teacher's racist and hostile attitude towards her and a fellow Black student. The content of the actual mathematics taught was barely recalled.

The competitive nature of traditional classrooms is thought to be hostile to Black students. A more co-operative classroom culture, where it is assumed that all can and will learn is more helpful. High achieving African American students reported that they acquiesced to the culture in order to become successful. (Moody, 2003). I have not come across similar studies done in South Africa, but much of what is reported above resonates with anecdotal evidence from Black learners in well resourced schools in South Africa and Brodie and Pournara (Brodie & Pournara, 2005) remind us that "in mathematics classrooms, power relations between learners play out in complex ways, in relation to race, gender, class, language, and mathematical competence" (p. 45). Following his analysis of the process of integration in South African schools, Soudien (2004) concludes: "Integration in education in South Africa can be argued to be a process of accommodation in which subordinate groups or elements of subordinate groups have been recruited or have promoted themselves into a hegemonic social, cultural and economic regime at the cost of subordinate ways of being, speaking and conducting their everyday lives" (p. 112).

3.4.4 Gender factors in the achievement of mathematical proficiency

Gender differences in mathematics participation, achievement and learning styles have been the focus of research over the past few decades, with the research indicating "different and sometimes contradictory findings" (Benn, 1997, p. 125). Benn considers that the research results indicating a variation in gender differences from country to country suggests that "any problems girls, and hence women, have with mathematics is less likely to be a biological than a social construct" (p. 125). The areas of research in mathematics and gender fall broadly into the categories of mathematical achievement, participation in mathematics, attitudes towards mathematics and mathematics learning. Although much of the gender related research discussed below was conducted in schools, we can expect that gendered patterns of mathematical experience, like mathematics anxiety "would appear to have its origins in early schooling but its effects can still be acutely felt in adulthood" (Macrae, 2003, p. 103). Consequently, the research with younger women and girls, is likely to be relevant to the preservice teachers in this study, some of whom are returning to the study of mathematics after several years.

"As women's and girl's aspirations have changed over the past decades, so too have the patterns of achievement and participation in mathematics" (Benn, 1997, p. 124). The principle of educational equity is accepted in most democracies and Leder (1992) concludes that "today the formal rights of all citizens to education, irrespective of sex, class, race or religious beliefs, tend to be taken for granted" (p. 599). Boaler, Brown and Rhodes (2003) report that in England the achievement of girls in mathematics had been increasing steadily over recent years until in 1995 equal numbers of girls and boys attained top grades in the school leaving examination. The TIMSS 2003 study reported that, in line with the international results, the difference in the South African national average mathematics and science scale scores for girls and boys was not statistically significant (Reddy, 2006b). This was an improvement over the TIMSS 1999 result where "the mathematics and science scores of girls in ex-African schools were statistically lower than the boys" (Reddy, 2006b, p. 113). A related finding of the TIMSS 2003 study was that, in most countries, including South Africa, there were equitable participation rates in mathematics and science classes between girls and boys. When the participation in South

Africa was considered by province, it was found that in the Eastern Cape and Gauteng about 8 per cent more girls than boys participated (Reddy, 2006b). It seems then, at school level at least, gender is becoming a decreasingly significant factor in the achievement and participation of girls in mathematics. Affective factors, however, are still thought to be important.

"Boys and girls differ in how they explain to themselves (and to the researchers who interview them) both their current and past successes and failures in mathematics" (Tobias, 1993, p. 80). In line with other disempowered groups, girls attribute their success to effort, luck or a helpful environment, and their failure to a lack of ability. In contrast, boys attribute their success to their ability, and their failure to insufficient effort. This matters, since while on the one hand, such attributions erode the confidence of girls who become fearful that their effort will be insufficient to master more advanced mathematics, on the other hand, those who attribute success to ability have "every reason to expect success in the future, because ability will remain relatively constant" (Meyer & Koehler, 1990, p. 66). We are cautioned, however, by Whitley, McHugh and Frieze (cited in Leder, 1992), that the publication bias towards studies in which significant findings are reported has led to an unfounded exaggeration of gender differences in attributions for success and failure.

Boaler et al. (2003), after extensive reviews of the literature, contend that one of the most consistent and strongest messages is that "the attitude and attainment of girls is improved by mathematical environments that are based on problem-solving and that include group work in non competitive settings" (p. 94). This is borne out by the findings of a study of high ability girls in the top set which indicated that girls responded badly to the high pressure, competition and fast paced lessons that were features of the top set environment, and this caused them to reject mathematics (Boaler, Brown, & Rhodes, 2003). Benn (1997) reports that many gender-aware teachers in the field of adult education successfully utilise approaches that include collaboration and sharing of control, co-operation rather than competition, autonomous and self-directed and self-controlled learning behaviour, and a pedagogy which allows for and learns from error and conflict" (p. 135).

While it is important to take cognisance of the gender differences discussed above, Leder (1992) notes that in many cases "consistent between-gender differences are dwarfed by much larger within-group differences" (p. 607), and the interaction of gender differences with differences in race and social class for example, should be considered.

3.4.5 Disenchantment with mathematics

A recurring theme in many of the studies of people's mathematics autobiographies is the transition from regarding mathematics in a positive light to a more negative regard, normally as the result of what I term a "critical incident" signalling the breakdown of mathematical learning. The word disenchantment drawn from Gibson and Costello (2000), captures for me, the essence of this theme. Disenchantment is defined as "the feeling of being disappointed with something and no longer believing that it is good or worthwhile" (Sinclair, 1993, p. 402), or "the loss of good feeling about something; the loss of happiness about, satisfaction with, or enthusiasm for something" (Microsoft® Encarta® Reference Library, 2003). The theme of disenchantment, under various names, has been described in many studies. Tobias (1993) notes that the maths autobiographies of math anxious college students and adults reveal that they reach a point (in a presumably regular and linear sequence of work) when they sense that from that moment on, as far as mathematics was concerned, they were through. It is thought that their mathematical inability was masked by standard procedures and the way everything was tested in bits and pieces and students were never asked to work with the big picture. All of a sudden they realise that they are lost. This "sudden death" experience referred to by Tobias (1993, p. 52) has a parallel in the notion of a "brick wall" suggested by Coben (2000). She refers to the theme from mathematics autobiographies, of a brick wall as the point (usually in childhood) at which mathematics ceased to make sense; for some people it was long division, for others fractions or algebra. Some people never hit the brick wall, but for those who did, the impact was often traumatic and long-lasting. The point of transition may occur at any time on the course of the students' mathematical experiences. Duffin and Simpson (2000) cite a study of PGCE students by Cooper in which "he found that students reported having enjoyed mathematics at school, but their descriptions of their attitudes to university mathematics mirror those above (positive to negative attitude transition of school going students), giving a sense of themselves as unintelligent despite having what others would consider to be an excellent mathematics background. Cooper called this movement, from enjoyment to dislike, 'cooling out'" (p. 83). Ellsworth and Buss (2000) found that the transitions in attitudes were most often associated with individual teachers, or students' confidence to learn a specific concept such as geometry. Often experiences changed from year to year and the transition could be reversed. Sometimes students identify absence from school as the cause for their inability to do mathematics in a phenomenon which

Tobias (1993) terms the "dropped stitch" in reference to knitting where such an error remains to mar a piece of knitting until the work is unravelled to the point of the error, the stitch picked up, and the knitting reworked. In support of this, Poiani (1981) identifies excessive absences from school that result in gaps in conceptual development as a common cause of mathematics anxiety. However, Tobias cautions that despite the fact that mathematics is especially cumulative in nature, "being sick or in transit or just too far behind to learn the next new idea is not reason enough for doing poorly at math forever after. It is unlikely that one missing link can abort the whole process of learning elementary arithmetic" (p. 61). Maths anxious people use this reason as an excuse but cannot explain why, in later years, they have not returned to pick up where they left off since as adults they would learn the concepts more easily than children.

3.4.6 Adults returning to mathematics

In addition to the literature on adult learning in general, there is a growing body of literature on adults learning mathematics. As far back as 1981, the challenge of increasing numbers of adults with perceived mathematics deficits wishing to study in the humanities was noted. Where mathematics requirements were put in place, it became evident that "an increasingly large proportion of the students proceeding to higher education lacked the necessary mathematical prerequisites" and the numbers were swollen by the "new demand of many disciplines - conspicuously, the social sciences - for a mathematics qualification for their majors". (Hilton, 1981, p. 81) . The advice that Hilton (1981) offered twenty five years ago stills rings true: "We must teach these people good, useful mathematics in a low-key, relaxed style, free from authoritarianism, so that they come to feel not threatened by it, not daunted by its unfamiliar symbols, but comfortable with it and convinced they are now better able to reach rational decisions and cope with our complicated world" (p. 81).

Following her work with working-class adults who did not receive adequate mathematics instruction when they were at high school, Frankenstein (1998) indicates her "belief that development of self-confidence is a prerequisite for all learning" (Introduction section, para. 2). In this same vein, Duffin & Simpson (2000), suggest that the aim should be to move adult learners to see maths as a goal (a state the learner wants to be in, and through their actions tries to approach) rather than an anti-goal (a state the learner wishes to avoid, and through their actions, tries to move away from). Many adults return to mathematics to redeem a failure in the past, or to make up some deficit, and they often have expectations about how mathematics should be taught and just want to be told the rule, or given some drill and practice teaching despite the fact that they are unlikely to find value in such teaching. "Even if they are aware that such teaching methods have failed them in the past, they may see previous failure as something wrong with them rather than something caused by a mismatch in the classroom" (p. 94). Finally, they warn that: "The fact of that failure is often, of itself, sufficient to have made mathematical situations anti-goals for the learners involved and this brings with it emotional indicators which can prevent an otherwise intelligent adult from attempting any form of mathematical task. The development of the anti-goal nature of mathematics has come from their learning in school and, perhaps from a mismatch between the learner's way of thinking and the teacher's style" (p. 97).

Sanders (2006) has suggested that Ajzen's Theory of Planned Behaviour could provide a theoretical framework for understanding the engagement of teachers with the demands of curriculum change. This theory takes account of the external forces which can prevent a behaviour happening, even if an individual is favourably disposed and intends to act in a certain way by including a personal factor, perceived behavioural control, which concerns the degree to which one believes that one will be able to perform the behaviour. Perceived behavioural control is affected by control beliefs (beliefs about the presence of resources and opportunities that are needed for the behaviour, and the absence of obstacles to the behaviour). This may include beliefs about internal factors (for example one's abilities, skills, and intentions) as well as external factors (factors beyond the control of the individual, for example, time, opportunity, dependence on others). In the context of this study, I understand this to mean that a person's intention to engage with the MLE module is influenced by their self-efficacy beliefs and their locus of control. In other words, despite good intentions and wanting to engage with the work, there is a disabling belief that they are not able to do so because of personal or environmental factors such as those discussed earlier in this chapter.

It is clearly important that those who undertake the task of teaching adults mathematics, appreciate that a large part of their task is to increase motivation to learn, and that they have some guidelines for practice.

3.4.7 Enhancing adult motivation to learn

Many of the participants in my study were mature students, and all were at least 18 so that they fall into the category of adults learning basic mathematics and second chance learners. There are particular challenges to teaching adults and approaches that are not necessarily the same as those employed in school. The growing body of literature on adult motivation and learning provides a relevant theoretical framework for evaluating practice.

Since, as the title of Thoms' paper (2001) implies, "adults are not just big kids", it follows that adult learners will be motivated by different factors than children, and that teaching strategies successful with children might be less so with adults. Wlodkowski (1999) sees "five pillars on which rest what we as instructors have to offer adults" (p. 25). These are:

1. Offering expertise: the power of knowledge and preparation
2. Having empathy: the power of understanding and compassion
3. Showing enthusiasm: the power of commitment and expressiveness
4. Demonstrating clarity: the power of organisation and language
5. Being culturally responsive: the power of respect and social responsibility

These can be used both as guidance for practice, and as a yardstick to measure the effectiveness of the pedagogic practices employed in adult teaching. Each will be discussed in turn.

Offering expertise

This pillar, strongly related to the idea of teacher knowledge and competence, is described by Wlodkowski (1999) as being threefold: (a) knowing something beneficial to adults; (b) knowing that well and (c) being prepared to engage with the content with adults. Teacher competence is especially important in adult education where the teacher is an adult among adults and "cannot count on the customary advantage of age, experience, and size for extra leverage or added influence as an elementary school teacher might" (p. 27). Knowing the subject content well allows for maximum engagement with the students as the teacher is not tied to the lecture notes.

Having empathy

Empathy is defined as "the ability to share another person's feelings and emotions as if they were your own" (Sinclair, 1993, p. 461). In the context of adult learning, this would mean firstly, a realistic understanding of the learners' goals, perspectives and expectations; secondly, an adaptation of the instruction to the learner's level of skills development and experience; and thirdly, a continuous consideration of the learners' perspectives and feelings (Wlodkowski, 1999). This entails taking the time to get to know the students on a personal level, and more importantly on a subject diagnostic level. As Wlodkowski (1999) reminds us, instructors in all fields "know from years of hard-earned experience that you cannot take anyone from anywhere unless you start somewhere near where they are" (p. 39).

Showing enthusiasm

Given that the teacher is expert and compassionate, the third pillar is enthusiasm defined as "a great eagerness to be involved in a particular activity, because it is something you like and enjoy or that you think is important" (Sinclair, 1993, p. 471). Wlodkowski (1999) suggests that a very important feature of enthusiasm as a characteristic of a good teacher is the intent to encourage learners to value their subject, a goal which "motivates us to have rapport with our students and to express our feelings in a way that engages learners to share in our enthusiasm" (p. 43).

Demonstrating clarity

This pillar, the fourth, is concerned with the way in which the teacher communicates with the adult learners. Instructional clarity is crucial since, as Wlodkowski (1999) reminds us, "people seldom learn what they cannot understand" (p. 52), and to a large extent, the language of the teacher mediates the learning. Two instructional strategies are proposed to enhance clarity: (a) initial careful planning of the instruction and course materials to ensure that the students have a good overall picture of the work and can monitor their own learning; and (b) having rescue plans, such as additional resources, tutorials and consultation times, for students who do not initially understand (Wlodkowski, 1999).

Being culturally responsive

This fifth pillar is a new addition appearing in the second edition of Wlodkowski's book on motivating adult learners (Wlodkowski, 1999), and reflects the growing awareness of respect for diversity. Wlodkowski (1999) explains respect for diversity as "an understanding that people are different as a result of history, socialisation, and experience as well as biology. Thus learners have different perspectives, and all of them have the right to instruction that accommodates this diversity….This understanding obliges me to see my work in the context of an ideal for social justice" (p. 60). Although gender issues are not explicitly mentioned, this pillar can be construed to include being respectful of both genders as well.

3.5 SUMMARY

Successful mathematics learning has been described using the construct of mathematical proficiency, with particular focus on the strand of productive disposition. This, together with the conceptions of learning and constructivist learning theory, provides a theoretical framework for analysing the data on preservice teacher learning in the MLE module. Barriers to learning mathematics, particularly in the South African context, were discussed and the literature relating to language issues, affect and the state of schooling in South Africa was consulted and discussed in order to inform the analysis of the stories the preservice teachers wrote about their schooling experiences. Finally, the literature on motivating adult learning, and adult mathematical learning was reviewed to provide a lens through which to view the pedagogical practices employed in the teaching of the MLE module.

Against this theoretical backdrop, in the following chapter I will describe the research methodology employed in this study, and how the diverse research instruments were used to weave a strong rope of evidence to describe the case of the MLE module, and to answer the research questions.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

The personal motivation for this study (see section 1.3) was to develop an understanding of the learners who find themselves in a mathematical literacy course as a prerequisite for their chosen career, and how they are best enabled to learn. This was done with an orientation towards social justice research. The study was focused firstly on the productive disposition strand of mathematical proficiency of the preservice teachers, both before and after the MLE module. This was informed by quantitative analysis of questionnaires and written mathematics content, and by qualitative analysis of written mathematical autobiographies, interviews and reflective writing. The second focus is on the pedagogical practices and learning behaviours that enable successful learning within the MLE module. In this chapter, the philosophical orientation of the researcher is discussed, the research is identified as a case study, the research design is explained and the fit of the research methods to the research questions is explained. In addition, the instruments chosen are discussed and the progression of the study and key research decisions are described. This is done in detail to provide the connections between my questions, the methods of data collection and the analysis.

Popular understandings of research often assume that a chain of evidence is required to link the research problem to the final solution. A chain derives its strength from the strength of each link and is only as strong as the weakest link so that ideally all links in the chain should be equally strong. However, if we are convinced by the critiques of research instruments such as questionnaires, interviews, life histories and reflective writing, they have the potential to undermine our confidence in the validity of the data generated. We may begin to doubt the strength of the individual links in the chain of evidence, and therefore the credibility of the assertions made as a result of research. Instead of the analogy of a chain, the analogy of a rope is helpful here. A rope works on an entirely different principle to a chain. Its strength is derived from the combined strength of many relatively weak strands twisted together and any weakness in one strand is compensated for by the strength of another. This research design follows the rope model. The strength of the rope of evidence presented here comes from the meshing of data derived from 254 students and 12 co-workers, nine research instruments and three consecutive cycles of research.

It is appropriate though, at the outset and before the detail of the actual research is given, to reveal the philosophical orientation of myself as the researcher and the research, as this frames the study.

4.1 PHILOSOPHICAL ORIENTATION OF THE RESEARCH

In this section, the relationship between the qualitative/quantitative debate and the paradigm wars is discussed, and an attempt made to disentangle the philosophical orientation of the research from the research methods used. I identify completely with Boylan (2000) who admits that it is "difficult to summarise even those aspects of my ideological position that I am critically aware of, not least because it is developing and changing, let alone those aspects I am more dimly familiar with" (Limits of the paper section, para. 3). This said, and acknowledging the importance of an up-front statement of the philosophical stance of the researcher, and following a brief overview of the extreme and middle positions, I identify myself as operating in the pragmatist paradigm with an orientation towards social justice.

At first encounter, it is difficult to see why the qualitative/quantitative debate is given so much prominence in the literature, and why a researcher should feel pressured to choose a side. Common sense would seem to lead a researcher to the "side" that promises to go some way to answering the research questions and deepening understanding of the issue in question. Griffiths (1998) provides some insight into why the debate has acquired significance: "Allegiances to particular forms of research, qualitative and quantitative, have political and ethical overtones, which generate heat. By now the debate also has a history, even mythology: this is dust which can obscure the issues as they apply in current contexts, but it is also dust which has permeated the issues and has to be recognised as changing their present nature" (p. 13).

At the extreme, quantitative survey research looks for numerical differences between two groups of people along some activity or background from which they can infer an explanation for the act based on the logic of the difference between groups with different traits. This type of research is commonly used in large scale experiments, for example drug trials where some physical attribute of subjects taking the drug would be measured and compared to another group of subjects not taking the drug. The public understanding of such research is that it is scientific and the results clear cut. The likely inference is that researchers working in this quantitative mode would subscribe to the positivist school of thought, and as such would assume an objective external reality which could be investigated by traditional scientific means to establish the laws governing that reality. At the other extreme, "qualitative researchers believe that only qualitative data respect the complexity, subtlety and detail of human transactions" (Basit, 2003, p.146), and so they seek to describe situations and inductively ascribe meaning to situations. The likely inference in this case, is that researchers in the qualitative mode are interpretivists or constructivists who assume only subjective realities that cannot be fully known. It can be argued that it is these inferences that have political and ethical overtones, more than the research methods per se. In other words, the qualitative/quantitative debate is not really about the research methods to use, but about the paradigms that have become associated (rightly or wrongly) with each methodology, with quantitative being a proxy for positivist and qualitative a proxy for interpretivist or constructivist.

The issue of the philosophical position of the researcher is thus crucial. In support of this, Olsen (1995) in an article aptly titled *Quantitative 'versus' Qualitative Research: The wrong question* claims that it is the ontological and epistemological stances of the researchers that are more indicative of the perspectives adopted in the research study than the methodology used. Guba and Lincoln (1994) suggest that "questions of method are secondary to questions of paradigm", which they define as "the basic belief system or worldview that guides the investigator, not only in choices of method but in ontologically and epistemologically fundamental ways" (p. 105). Furthermore, as Guba and Lincoln (1994) remind us, "differences in paradigm assumptions cannot be dismissed as mere philosophical differences: implicitly or explicitly, these positions have important consequences for the practical conduct of enquiry, as well as for the interpretation of findings and policy choices" (p. 112). Dobson (2002) endorses the importance of engaging with philosophical issues by asserting that: "The confidence provided by understanding different philosophical positions provided the researcher and the practitioner with the power to argue for different approaches and allows one confidently to choose one's own sphere of activity. The emancipatory potential of such knowledge is a powerful argument for bothering with philosophy'" (Dobson, 2002, Why bother with philosophy section, para. 2).

With the above in mind, it is appropriate at this point in the dissertation, to locate this research within a particular paradigm which clearly will reflect my ontological and epistemological views. It should be appreciated that while the descriptions of paradigms provided in the literature might be neatly tabulated to show points of similarity and difference (see for example Guba & Lincoln, 1994, p. 112), the complexity of human personalities makes it unlikely that any person would find themselves completely in accord with any one paradigm. Certainly I see more fuzzy boundaries. Few would argue with the paradigms of positivism and constructivism being conceived as the opposite poles of a scale of beliefs about the nature of reality (ontology) and the relationship between knowledge and the knower (epistemology). There are two different claims for the middle ground: critical realism and pragmatism, each of which will be discussed in turn.

The claim for the middle ground of critical realism is based on its position between the extreme view of reality being absolute and fixed, and the view that reality is purely subjective. Critical realism "provides a useful basis for bridging the dualism between subjective and objective views of reality: real objects are subject to value-laden observation" (Dobson, 2002, Conclusion section, para. 1). According to Dobson (2002), the critical realist identifies two dimensions, the intransitive and relatively enduring dimension in which a reality totally independent of our representations of it exist, and a transitive and changing dimension in which the value laden observation of reality exists. The critical realist would refute the view that reality is a social product that cannot be understood independently of the social actors since reality pre-exists the transitive changing analysis of it. "For the realist, the most important driver for decisions on methodological approach will always be the intransitive dimension, the target being to unearth the real mechanisms and structures underlying perceived events" (Dobson, 2002, The object of research section, para. 1). Furthermore, although our perceptions of reality change, the underlying structures and mechanisms contributing to that reality are relatively enduring and "the aim of realist research is to develop a better understanding of these enduring structures and mechanisms" (Dobson, 2002, The transitive/intransitive divide section, para. 2).

A second and different claim for the middle ground comes from pragmatism which is endorsed by Johnson and Onwuegbuzie (2004) as a philosophy that can build bridges between the conflicting philosophies of positivists and constructivists. Pragmatism is the philosophical partner to mixed methods research which occupies the middle ground between quantitative and qualitative research (and their traditionally associated paradigmatic partners). "If you visualise a continuum with qualitative research anchored at one pole and quantitative research anchored at the other, mixed methods research covers the large set of points in the middle area. If one prefers to think categorically, mixed methods research sits in a new third chair, with qualitative research sitting on the left side and quantitative research sitting on the right side" (Johnson & Onwuegbuzie, 2004, p. 15).

Pragmatists, according to Onwuegbuzie (2002), accept the notion of external reality and believe that values play a role in the interpretation of results, accepting the existence of both objective and subjective points of view. Pragmatists advocate the use of mixed methodologies (i.e. combining quantitative and qualitative research designs) and draw on both inductive and deductive logic to produce explanations. This approach is well captured in the words written in 1868, of Peirce (cited in Johnson & Onwuegbuzie, 2004): "Reasoning should not form a chain that is no stronger than its weakest link, but a cable whose fibres may be ever so slender, provided they are sufficiently numerous and intimately connected" (p. 18). Human inquiry, according to pragmatists, is analogous to experimental and scientific theory. "We all try out things to see what works, what solves problems, and what helps us to survive. We obtain warranted evidence that provides us with answers that are ultimately tentative (i.e. inquiry provides the best answers we can currently muster), but in the long run…move us toward larger Truths" (Johnson & Onwuegbuzie, 2004, p. 18). Bazeley (2003) agrees that the pragmatic approach is an eclectic one in which any data or approaches to analysis that contribute to an understanding of the issues at hand are seen as worthy of consideration. The human aspect is not overlooked because one of the 22 general characteristics of pragmatism suggested by Johnson and Onwuegbuzie (2004) is that it "takes an explicitly value-oriented approach to research that is derived from cultural values; specifically endorses shared values such as democracy, freedom, equality, and progress" (p. 18). The pragmatic paradigm resonates with my world view and consequently is the explicitly stated paradigm underpinning this research study.

Once researchers have clear self knowledge of their world view which they will make explicit in their research report, it remains for them to choose the most apt research methodology for the research problem. What is considered apt will be governed by both the nature of the research problem and the philosophical position of the researcher. Olsen (1995) urges researchers to be open and cognisant of their ontological and epistemological standpoints, and thereafter to feel free to choose methodology as is appropriate to the problem in question without needing to declare allegiance to either side of the qualitative versus quantitative debate. After a discussion of five studies in the Library and Information Studies field in which subjective aspects (for example interviewer prompts in open questions) were found in objective survey type research, she contends that "there is considerably more overlap than the voices in the quantitative versus qualitative debate imply" (Olsen, 1995, Research studies section, para. 7). Becker (1996) too contends that there is a lot of overlap in researching in the quantitative style and the qualitative style since in a sense the styles imply each other as "every analysis of a case rests, explicitly or implicitly, on some general laws, and every general law supposes that the investigation of particular cases would show that law at work" (p. 53). After acknowledging that many research studies include both quantitative and qualitative aspects, Griffiths (1998) takes the position "that qualitative research is research that uses at least some data that are not susceptible to numerical analysis" (p. 14). In addition to the views above which indicate that in many instances research projects are de facto a mix of qualitative and quantitative methods, there seems to be agreement in the literature that regardless of the paradigm in which the research is situated, and the perspective from which the research is conducted, either method can be used if appropriate. "Clearly, educational research for social justice is a huge area. I want to point out that it includes both quantitative and qualitative research" (Griffiths, 1998, p. 13). Guba and Lincoln (1994) concur, writing that "from our perspective, both qualitative and quantitative methods may be used with any research paradigm" (p. 105). Within a critical realism framework, both qualitative and quantitative methodologies are seen as appropriate, and the seeming dichotomy between the two is replaced by an approach that employs the methodology considered most suited to the particular research questions and research contexts. The possibility of complementarity of methodologies is recognised (Krauss, 2005). However, Bazeley (2003) while conceding that the paradigmatic approach taken by the researcher does not preclude particular types of data nor particular tools for data analysis, nevertheless reminds us that "the researcher's paradigmatic approach can, however, greatly influence the way in which those tools are used and the method and style of interpretations derived from the data" (p. 389). Within the pragmatic framework, mixed method research is advocated where the choice is not whether to use qualitative or quantitative methods but rather how the two can work together to produce research that is superior to what could be achieved by either on its own.

The mixed method research approach employed in this study is fully discussed in the section dealing with research design which follows the next section in which this research project is identified as a case study.

4.2 CASE STUDIES

The identification of this study as a case study can be considered from the perspective of several writers in the field of educational research who have provided descriptions and criteria for such a classification (see for example, Bassey, 1999; Bogdan & Bilken, 1992; L. Cohen, Manion, & Morrison, 2000; Henning, 2004; Merriam, 1988; Yin, 2003). This study will be discussed in the light of the interpretations of Merriam (1988) and Bassey (1999), in order to provide a solid basis for the applicability of the research design.

Merriam (1988), suggests that researchers consider the nature of the research questions, the amount of control one can exert over the research, the desired end product and the boundedness of the system to be researched before deciding that a case study is the appropriate design for investigating the problem of interest. Case study research is appropriate firstly when the researcher has research questions related to interesting aspects of an educational activity, programme or system (Bassey, 1999) and these questions are focussed more on asking how and why, as opposed to, for example, how many (Merriam, 1988). This study was based on aspects of the MLE module that were of interest to me, and with important implications for the wider mathematics education community and tertiary education institutions. Secondly, the research should be conducted within natural contexts and with an ethic of respect (Bassey, 1999), in other words, as Merriam (1988) describes it, with minimal control, implying that the researcher is unable or unwilling to manipulate events. This does not preclude studying a teaching programme which may be informally controlled by the researcher, but rather is intended to preclude experimental type research methods where participants are subject to different treatments and interventions. Both the criteria for conducting the research in natural contexts, and the further condition suggested by Yin (2003) that the events being researched be contemporary suggest that case study research is appropriate in this instance where the MLE module was investigated as it unfolded. Thirdly, case study is only appropriate when the study is concerned with a bounded system (Merriam, 1988), which is described by Bassey (1999) as conducting the research in a localised boundary of space and time. The bounded system in question may be any social entity (a group of people, a set of documents, a television series) that can "be bounded by parameters and that shows a specific dynamic and relevance, revealing information that can be captured within these boundaries" (Henning, 2004, p. 32). This study was designed to research a single module, taught on one site over the initial three years of its inception, making the study particularistic and of a singularity. The case that is to be studied does not cease to exist once the researcher moves on and often subsequent events occur that might alter the initial interpretations of events. However, Lincoln and Guba (1985) urge writers of case study reports to have a firm termination date in mind for the case, this being the date "beyond which events reported and interpreted in the case study will no longer be changed" (p. 366). Following this advice, the study of the case in this instance, was terminated at the end of 2005. The three criteria identified above as indicators for a case study to be a suitable research design, all apply to this study.

The next issue for consideration is the classification of the case study according to its purpose. Bassey (1999) argues that there are at least three categories of educational case study. Firstly, there are theory -seeking and theory -testing case studies which each present a convincing argument for a fuzzy generalisation or more tentatively a fuzzy proposition. "These are particular studies of general issues. The singularity is chosen because it is expected in some way to be typical of something more general. The focus is on the issue rather than the case as such" (p. 62). In this study, the singularities, i.e. the preservice teachers forming the three cohorts of MLE students and the MLE module itself, instantiate students who enter higher education with an unsuccessful mathematical histories, and foundational mathematics modules that serve as gatekeepers to humanities degree programmes respectively. Theory - seeking case study is akin to what is termed an exploratory case study by Yin (2003) and described by Merriam (1988) as an interpretative study to generate knowledge inductively. A theory-testing case study is interpretative, and designed to challenge or support existing assumptions (Merriam, 1988), and is like an explanatory or causal case study (Yin, 2003). Secondly, there are story-telling or picture-drawing case studies which present analytical accounts of educational events, projects, programmes or systems in order to illuminate theory. A story-telling case study is presented as a "narrative account of the exploration and analysis of the case, with a strong sense of a time line" (p. 62). A picture-drawing or portrayal case study is a more descriptive account of the results of the exploration and analysis of the case. Theoretical insights may emerge but in a more discursive form than a fuzzy generalisation. Such case studies are generally termed descriptive case studies. Thirdly, there are evaluative case studies which are more tightly structured explorations of educational events, projects, programmes or systems usually undertaken in order to establish worthwhileness. In line with their purpose, such studies draw on theoretical notions but are not necessarily intended to contribute to theory.

A study may include more than one type of case study either in parallel, or in embedded relationships with each other (Bassey, 1999). In this research project, the three successive cohorts of preservice teachers form the unit of analysis for the first two research questions, namely those relating to the productive dispositions of students entering and exiting the MLE module. This case study is descriptive and of the picture-drawing or portrayal type, with a tilt towards a theory seeking case study. The third research question, dealing with the pedagogical practices and learning behaviours within the module, forms the object of a second case study, which is story telling in the sense that the events of the module will be described and analysed in narrative style, with a tilt towards being an evaluative case study. These two case studies overlap and are embedded within the larger case study of the MLE module.

Once the purpose of the case study is established, suitable data collection strategies become evident, as does the nature of the eventual output. Henning (2004) advises that she has "found that that case studies require multiple methods in order to truly capture the case in some depth" (p. 42). The study of the case is organised by the issues that seem most compelling to the researcher (Stake, 2000). These issues are described as matters for study regarding the specific case and Stake (2000) describes a sequence of study in which the researcher begins with a topical concern, poses foreshadowed problems, concentrates on issue related observations and finally interprets patterns of data that reform the issues as assertions. The foreshadowed problems must not be equated with preconceptions that could hinder authentic research but should rather seen as the product of studies of the literature and experience. "Somehow a balance must be struck between recognising preconceptions and using one's present understandings and beliefs to enquire intelligently" (Walford, 2001, p.9). Furthermore, Dey (cited in Walford, 2001) stresses the difference between an open mind and an empty head, and reminds us that the danger is not so much on having assumptions as being unaware of them. Clearly, the foreshadowed problems become the phenomena, themes and issues to be studied and are frequently synonymous with the research questions.

The next conceptual responsibility of the case study researcher is data analysis which involves seeking patterns of data to develop the issues and then triangulating key observations, and seeking alternative interpretations to pursue (Stake, 2000). "Data analysis is the most difficult and most crucial aspect of qualitative research" (Basit, 2003, p.143). Unlike some quantitative research projects, where the data collection and analysis is often done by different people, most qualitative researchers analyse their own data since it is not fundamentally a technical process but rather "a dynamic, intuitive and creative process of inductive reasoning, thinking and theorising" (Basit, 2003, p.143), requiring an iterative process with no shortcuts, and drawing on a blend of the researchers' understandings of analysis, the conventions of their disciplines and professions, advice of mentors, models internalised from the literature and personal intuition. Cresswell (1994) describes the data analysis process as involving taking apart the data into small chunks (which removes the context), and then constructing a bigger consolidated picture which is then recontextualised. The qualitative researcher describes all the contextual factors surrounding the act and sees how it is all connected. While the data collected in a survey is often bounded by what is asked precluding any surprise data, qualitative fieldworkers are open to adding variables and ideas to their models as they encounter things that might have a bearing on their subject. In this study, the intention was to allow many voices to tell the stories of their mathematics experiences and one of the product of the data analysis and careful examination of the "chunks" is a series of polyvocal fictional letters containing the assertions and generalisations about the case.

In summary, this study was an empirical enquiry into a singularity which aims to inform judgements of practitioners or policy makers. Sufficient data was collected to explore significant features of the case and create plausible explanations. The fulfilment of the aforementioned criteria establishes it as a case study.

4.3 THE RESEARCH CONTEXT

The research context has been described in Chapter 2 where the positioning of the Mathematical Literacy for Educators (MLE) module within international contexts, in the South African national policy documents for both schooling and higher education, and within the Faculty of Education at University of KwaZulu-Natal (UKZN) is discussed. In summary, the MLE module was a compulsory module, in the first year of study, for preservice teachers without a pass in Grade 12 mathematics. The focus was on personal mathematical literacy and not teacher preparation as these preservice teachers were planning to teach a range of subjects (but not mathematics) in the secondary school. Crucial to understanding the research context, is the knowledge that I was at the same time researcher, curriculum designer, learning mediator and module administrator. The primary focus was on the teaching of the module since there was a clear moral accountability to students who were paying to learn from the MLE module and not to further my research interests. Consequently, although some of the data was specifically collected for research purposes, most of the data collecting opportunities were in the course of learning activities which had clear pedagogical purposes.

4.4 SIMILAR STUDIES

It is instructive to consider the work of other researchers who have conducted similar studies, in order gain insight into promising approaches and to be alerted to possible problems. Krauss (2005) has written about the value of combining both qualitative and quantitative methods following his study of the religiosity of young people. Combining both methods resulted in "a major study that tapped into the richness of individual religious experience, along with a broader understanding of religious behaviours and knowledge levels across large groups of young people" (p. 758). This has a clear parallel to the work of this study which seeks both to describe the individual mathematical experiences of preservice teachers and also to understand emotional and knowledge characteristics of groups of students engaged in a particular mathematics learning situation.

Another related study involved classroom research in an introductory statistics course. The authors, (delMas & Chance, 1999) state the main aim of such classroom research is to "gain insight into problems, their definitions and their sources" (para.1), and in contrast to more traditional research, neither attempts to answer questions definitively nor to find the solutions to problems. DelMas and Chance (1999) acknowledge that the results of many classroom studies may be not viewed as suitable for dissemination since they often focus on a particular classroom setting with anecdotal information and are not always generalisable. However, they contend that when ongoing classroom projects are done carefully they may yield valuable insights into, in the case of their research, the teaching and learning of statistics.

DelMas and Chance (1999) structured their research design on the following four steps, phrased as questions:

1. What is the problem? The identification of the problem emerges from experience in the classroom as the teacher observes students, reviews student work, and reflects on this information.
2. What technique can be used to address the learning problem? This could be a new instructional technique, alternative materials or modifications of the above.
3. What type of evidence can be gathered to show whether the implementation is effective? This raises issues of assessment and evaluation of data.
4. What should be done next, based on what was learned? Is there still a problem and if so what further modifications might be helpful?

Basit (2003) considers her study of a group of trainee teachers moving into practice as mathematics teachers as an attempt to paint a picture of the group as a single case. "A case study examines a single instance, which could be a pupil, a class, a group, a community or a profession, to illuminate the wider population to which it belongs" (Basit, 2003, p. 146).

The study reported by Evans (1994) has many similar aspects to the study described in this thesis. He gave over 900 participants questionnaires concerning biographical data, and items selected from the Mathematics Anxiety Rating Scale. Implicitly, the biographical information asked for is chosen because of the researcher's belief that these factors will contribute to the explanation of performance. The quantitative data were used to look for gender differences which seemed at first analysis to be significant, but were considerably less so when a regression analysis controlled for age, mathematics test anxiety and mathematics training was carried out. This illustrates the usefulness of statistical analysis in understanding a situation. Evans (1994) explains how he used two qualitative approaches: Firstly, a cross subject approach which aimed to consider in a comparative way the results from all the interviews and secondly, each interview was considered as a case study of a particular student's thinking and affect. He concludes that: "The quantitative approach is useful when we wish to make comparisons across subjects, or groups of subjects, and we aim for some degree of generality ... The qualitative case study approach is useful when we wish to explore the richness, coherence ... and process of development of a limited number of cases. The qualitative cross-subject approach provides an intermediate approach, for cases where it may be challenging to produce comparability across subjects, but where some generality in findings is sought" (Evans, 1994, p. 326).

4.5 RESEARCH DESIGN AND FIT TO INQUIRY QUESTIONS

This research is designed as two case studies embedded in, and contributing to, a wider case study of the MLE module. A mixed methods methodology is employed, with the qualitative and quantitative methods used largely in parallel in an effort to confirm and elaborate findings from one method by using the other. For example, the questionnaire item which asked respondents to choose words to describe their school mathematics experience was followed by an item in which respondents were invited to write a sentence describing their school experience. The sentences were analysed qualitatively for themes whose prevalence could be matched to the choice of the words. This is an instance of the classic understanding of triangulation in which "the researcher seeks to confirm his or her conclusions by using two or more methods to study the same phenomenon" (Bazeley, 2003, p. 394). In other instances, the quantitative data on an issue was used to generate themes (through exploratory factor analysis), that were used as a starting point for qualitative data analysis of text relating to the same issue. This is termed a sequential method within the mixed methodology terminology (Teddlie & Tashakkori, 2003). Inclusion of demographic data for cases where the primary data sources are qualitative is one of the most common forms of integration of qualitative and quantitative data (Bazeley, 2003), the assumption being that a person's age, gender, schooling experience and so on, is relevant to anything they might write or say. In this research design, the demographic data was incorporated into the NVivo project. The typologies for mixed methods research cited by Teddlie and Tashakkori (2003) mostly involve a decision about the priority to be given to each type of method, or a decision to accord them equal status. I did not choose to classify this research in such detail, as in fact, there are three research questions and nine research instruments where the interplay of quantitative and qualitative data varies. Sufficient to say that both qualitative and quantitative data are used in this study as appropriate.

The research design chosen must clearly match the research questions and provide opportunities to generate the data needed to answer these questions. This issue is addressed by considering the research questions in turn.

While the four content based stands of mathematical proficiency (procedural fluency, conceptual understanding, adaptive reasoning and strategic competence) can be assessed by examination of answers to mathematical questions, the productive disposition strand can only be assessed by the feelings and emotions that a person is prepared to reveal. In order to investigate the productive disposition strand, the question to be asked, both at the outset and at the completion of the module would be: To what extent do preservice teachers perceive mathematics as useful and worthwhile, see themselves as effective learners and doers of mathematics, and believe that it is worth the effort to become proficient? (RQ1 and RQ2). Questions such as these have no simple answers and even the best instruments would yield only partial insights. After extensive reading of different methodologies and similar studies, it seemed that a picture drawing case study of students embedded within the larger case study of the Mathematical Literacy for Educators module programme would be the most suitable approach to these questions.

The third research question, concerning the pedagogical practices and learning behaviours that best enable the development of mathematical literacy, relates to teaching and learning activities of the MLE module where the participants, preservice teachers, the researcher as teacher, and a variety of tutors and co-workers were mutually involved. Although the study of three successive cohorts of preservice teachers, and the efforts to improve practice might seem to signal that this study was an action research project, it was not designed as such. While many of the key steps for action research identified by McNiff and Whitehead (2005), namely identification and justification of the concern that prompted the research; the production of evidence to describe the current situation; the selection of a means of intervention; the production of evidence to describe the unfolding situation; the demonstration that the conclusions and assertions made are reasonably fair and accurate and finally the modification of practice in the light of what had been learnt, were present in this study it is not claimed as action research. This would rather be classed as teacher research according to the definition offered by Cochran-Smith and Lytle (cited in Breen, 2003, p. 528) where teacher research is taken to "mean all forms of practitioner inquiry that involve a systematic, intentional, and self-critical inquiry about one's work in educational settings." What distinguishes action research from teacher research is the insistence that teachers justify their claims to knowledge by the production of authenticated and validated evidence which they then open to public scrutiny and critical evaluation (McNiff & Whitehead, 2005), and the latter was not a feature of this study. There was no formalised attempt at self study and no critical friends to monitor interpretations. Rather, this research question was addressed by the construction of an evaluative case study embedded in the larger case study of the MLE module.

4.6 DATA GENERATION AND ANALYSIS BY INSTRUMENT

Over the three years of this study, a number of instruments were used to gather data. At the beginning of each teaching year, the students filled in an information sheet, and wrote a short mathematics autobiography. The initial lectures focused on the nature of maths and stressed the idea of a new beginning as adults learning maths. This entailed the construction of a Mathematics Bill of Rights and a preknowledge survey. Various informal writing activities throughout the module were used to gauge students' own perceptions of their progress. The final course evaluation was designed in conjunction with the Quality Promotion Unit (QPU) of UKZN in 2004, and slightly expanded in 2005 to include questions relating to the resources that were a new feature of the module. The QPU analysed the fixed responses by computer and typed up all the open responses.

Table 4.1 Summary of data corpus and data analysis methods

	Description	Data obtained	RQ	Method of analysis
1	Biographical data sheet and pre-module questionnaire	Description of school maths, Choice of words & sentences	1	Frequency counts NVivo for sentences
		Attributions of success at mathematics	1	Likert scale data means calculated. Exploratory factor analysis
		Reasons for taking maths to Grade 12	1	New variables identified and values computed. ANOVA to compare groups
		Reasons for not taking maths to Grade 12	1	according to gender, race, schooling and maths qualification
		Choice of teaching style Likert scale rating of styles	3	Counts and means for each style
2	Pre-knowledge survey	Preferred learning styles	3	Counts
3	Bill of rights activity	Attitudes to learning and being taught	1,3	Ranking of rights
4	Mathematics Autobiographies	Stories of school maths experiences	1	NVivo coding for emergent themes and themes from literature
5	How are you getting on?	(2004) Self - Rating of confidence & competence	3	Frequency of each response
		Uptake of resources provided		Link btw self-rating and final mark
		Language, pace & Classroom environment (fixed response 2005)		ANOVA to compare groups
6	Data course reflections	Test preparation: Time spent on tasks, study habits etc Mark expected or not Plans for improvement 2003 & 2005 cohorts only	3	Frequency of each response Discussion of qualitative data
7	Final course evaluations	About 40 items re lectures, tutorials, effort & motivation,& in 2005 resources. Rated on Likert scale Free response sentences after each section	2,3	Exploratory factor analysis and testing to validate instrument Frequencies and means ANOVA to compare groups
8	Interviews	38 interviews School maths experience Experience in module Change in attitudes	1,2,3	NVivo analysis according to codes arising from all previous instruments
9	Co-worker insights	Focus interview with tutors 2003; Journal entries from tutors 2004 Written answers to set questions 2005	1,2,3	NVivo analysis according to themes, both emergent and from other instruments

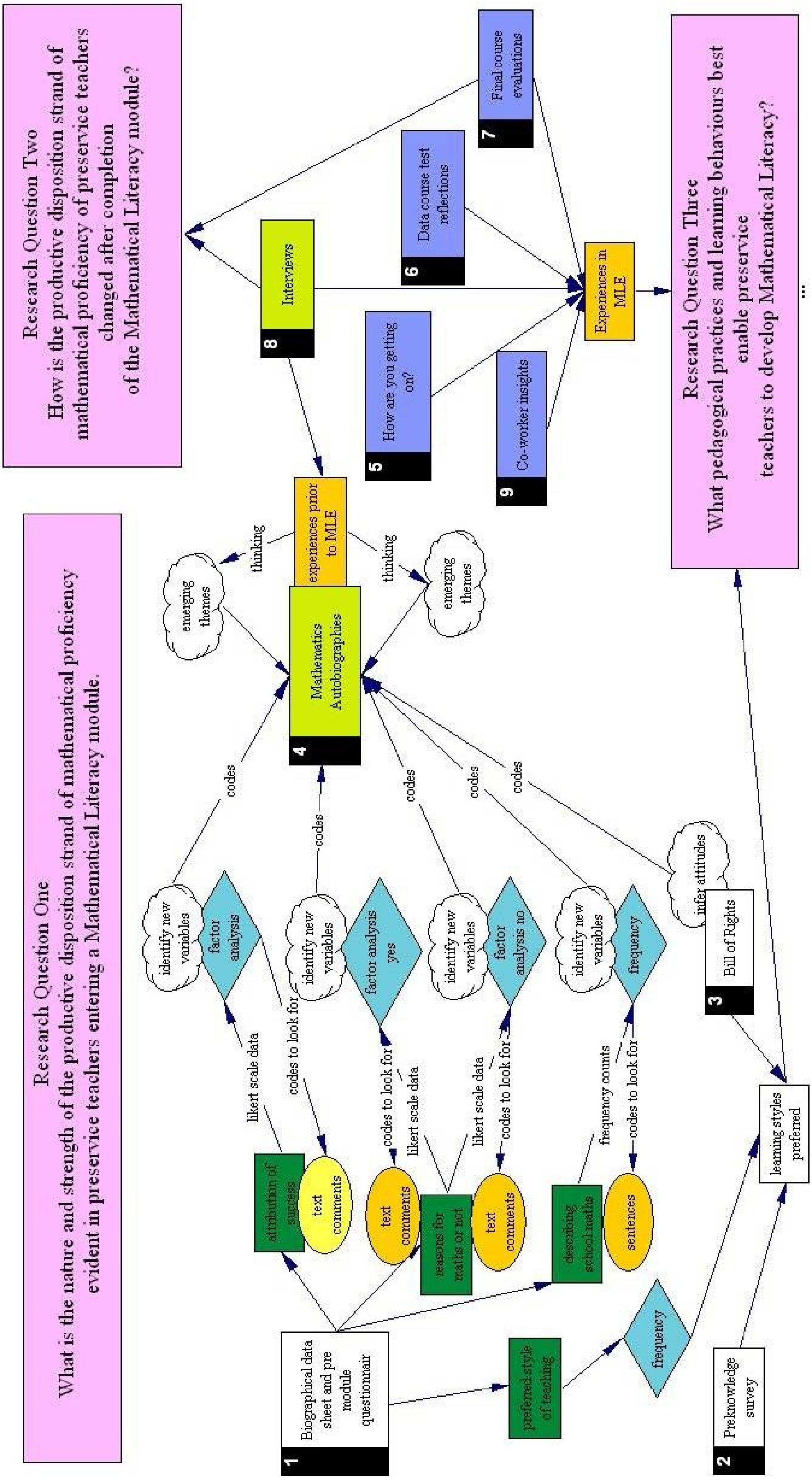


Figure 4.1 Research instrument and data analysis web

A global report on the module was prepared by their staff which provided an independent view on the students' responses. In 2003 I made a general appeal for students to be interviewed and 14 students responded and were interviewed. In 2004, I wrote different letters to repeat students, those who had failed, those who passed, and those with distinctions asking them to make appointments for interviews. I conducted 19 interviews. In addition, I taped my interactions with students in tutorial groups every now and again. In 2005, additional funding from the Access office of the university enabled me to do a project to encourage independent learning. As part of this, I have a video record of most of the semester lectures.

Each data collection instrument is fully described in the following sections. Firstly, as an organising framework for the readers, Figure 4.1 is provided to show the interrelationship between the data from the different instruments and the iterative nature of the data analysis. Secondly, and to the same end, a summary table of the data corpus, methods of analysis and the primary research question (RQ) addressed is provided in Table 4.1. The numbering of the instruments in both the diagram and the table corresponds to the order in which they were administered.

4.6.1 Instrument 1 Biographical information sheet and pre-module questionnaire

Description and pedagogical purpose

The questionnaire used in 2004 and 2005 is found in Appendix A. All the questions were asked in 2003 as well, but as part of a larger questionnaire found in Appendix I. Firstly, students were asked for their age and the year in which they finished school. I thought that this information would be important in the light of my perception of these students as being adults returning to mathematics. This perception would be most valid in cases where the student was not a recent school leaver, and I wanted the possibility of disaggregating the data on the basis of age and time lapse since school.

The second question required students to circle the phrase best which best described their school. The phrases were couched in terms of resources available at the school, and included Ex Model C schools as a separate description. These schools (previously attended by Whites only) are typically situated in upper middle class areas and the higher than average school fees are used to supplement the teaching staff and resource the school. In many ways they are semi-private schools and offer quality education to all race groups. Ex Model C schools were included as a separate category because research, (Khan, 2004), has indicated that African students attending such schools seem to escape the disadvantage of poorly resourced schools and second language instruction prevalent in township and rural schools. These students form a distinct and elite group (identified by not taking an African language in the Senior Certificate examination) with higher pass rates in mathematics and science than those African students who do take a African language and predominantly attend schools with a legacy of disadvantage.

Thirdly, the students were asked to circle two words, from a list of ten, which best described their experience of school mathematics. These words, which from my previous experience are used by people to describe mathematics, were equally divided into positive words (useful, easy, relevant, fun, rewarding), more negative words (difficult, humiliating, frustrating, irrelevant) and challenging which I considered a neutral word as it can be construed either positively or negatively. In this same question, students were asked to write one or two sentences summing up their school experience of mathematics.

The fourth question related to the factors that students perceived to have influenced their ability to do mathematics. This was a list of possible factors to be rated on a five point Likert scale ranging from "no influence at all" to "a very strong influence." Space was provided on the questionnaire for students to add any comments about influences on their ability to do mathematics.

The fifth and sixth questions concerned the reasons why students had either decided to terminate their studies of mathematics at Grade 9 level, or the reasons why they had decided to continue to Grade 12 level. The factors were matched as far as possible, so that for example, the factor "My parents didn't think I should take mathematics" was listed as a reason for terminating the study of mathematics at Grade 9 level, and the corresponding factor "My parents thought I should take mathematics" was listed as a factor in the decision to continue the study of mathematics. As in the fourth question, the students were asked to rate the influence of each factor on a five point Likert scale. After both the fifth and sixth questions, the students were asked to indicate if they thought they had made the correct decision and to explain their response.

The final question required the students to rate the usefulness of several styles of teaching for their learning of mathematics. The rating was done on a four point Likert scale ranging from "not helpful at all" to "very helpful." This question informed RQ3.

Data generating activity

In 2003, this information sheet was part of the final module evaluation form, as the data was collected mainly for my research purposes. On reflection, and following advice from senior researchers, it was decided to collect this data at the outset of the next cycle of the module to provide a better sense of the students' backgrounds while teaching the module. The questionnaires were completed during the initial lecture period in 2004 and 2005. The students who registered late were given the questionnaire in subsequent lectures and asked to return them completed by the next lecture. Defaulting students were reminded of this outstanding information sheet and eventually most were returned. Additional data, such as race, gender, matriculation exemption status and matriculation points scored, were obtained from student records.

Data reduction and analysis

The data from the questionnaires were captured according to a detailed codebook drawn up according to guidelines suggested by Newton and Rudestrom (1999). Accordingly, numerical values were assigned to each variable's values in the categorical data items such as gender, and to missing responses. Items such as age, and years since leaving school were self coding since the responses themselves formed the numerical codes. Each participant in the study was given a unique reference number and a master data spreadsheet created with the biographical data for each student. This allowed for subsequent disaggregation of the data according to all the biographical factors such as gender or type of school attended. The Likert scale responses were coded from 0 for "no influence at all" to 4 for "a very strong influence." This meant that all non-zero scores represented some influence with scores above three indicating a strong or very strong influence. Once all the data was entered, a process of data cleaning was undertaken. This was done by visually scanning the data set for gaps, and by producing frequency tables for each individual variable to check for values that were obvious errors of coding or recording. The free responses were typed out verbatim for analysis in a NVivo project together with all the other qualitative data from the particular student.

The data were initially analysed using NVivo2, and in the final stages of the study, using NVivo 7. These software packages, designed to aid the analysis of qualitative data, are the most recent versions of NUD*IST, an acronym for Non-numerical Unstructured Data, Indexing, Searching, Theorising. The full name indicates the scope of the programme. Within this software programme the source documents, in this case mathematical autobiographies, student interviews, reflective writing, module evaluations and so on, are allocated codes. Codes are labels attached to text (from single words to whole paragraphs or documents) for allocating units of meaning to the information collected in a study. The codes can be created two main ways: either by creating a provisional start list from the theoretical framework for the study, the research questions and key variables prior to the fieldwork and adding to this as necessary once the data has been collected, or by waiting for the data and creating codes as they arise from the text (Basit, 2003). The former method was used in this study, with the exploratory factor analysis of the quantitative data providing additional codes. Seidel and Kelle (cited in Basit, 2003) view the process of coding as noticing relevant phenomena in the data, collecting examples of these phenomena, and then analysing those phenomena in order to find commonalities, differences, patterns and structures. The code names can be derived from the text itself or come from the pool of concepts the researcher has from disciplinary or professional reading, and I used both sources for the names of the codes in this study.

The biographical data were analysed to describe the cohorts of students in terms of race, gender, age, schooling background and entry qualifications such as exemption status and matriculation points. Such descriptions give a rich context to the data and allow readers to judge whether the findings of this study might generalize to other contexts known to them. Simple counts were made of the number of times each of the ten words offered as descriptions of school mathematics experience were selected. The sentences written describing school mathematics experience were analysed qualitatively using the ten words as nodes, and according to any other themes which became apparent.

The Likert-type scales used in this questionnaire are ordinal scales. However, in practice most researchers, reassured by Zumbo and Zimmerman (1993) who see little harm in the practice, treat them as continuous variables provided there are at least five ordinal categories. If multiple items are combined by computing means for example, as with the new variables arising from factor analysis, the number of possible values for the composite variable increases beyond five and it is common practice to treat these composite scores as continuous variables.

The data relating to factors affecting the students' abilities to do mathematics were firstly analysed by computing the mean of the responses to give an indication of the overall student perception of the extent of the influence of each factor on their mathematical ability. Secondly, a factor analysis was used to extract components to make the analysis more focused. Initial analysis indicated three components and so a rotation was performed to generate a pattern matrix from which a table of factors loading onto each component was generated. These components were named, with reference to the commonality of the factors, as new variables, and values for these new variables were computed for each student by finding the mean of the factors loading onto that variable. A similar process of factor analysis and the creation of new variables was undertaken for the questions relating to the decision to continue or discontinue the study of mathematics past Grade 9. This process of creating new composite variables results in more robust data that can be subjected to t-tests and so on. The components identified were carried forward as possible codes to look for in the text comments that followed each scale, and later in the mathematics autobiographies and interviews.

Shortcomings and sources of error

The 2003 cohort of students answered questions related to their school experience after they had experienced the MLE module. This could have coloured their recollections and altered their perceptions of the past. The data required careful screening as some students confused the sections for those who had chosen to study mathematics to Grade 12 level with the section for those who had elected to discontinue with mathematics, or answered both sections. So they studied mathematics to grade 12 and yet filled in reasons why they had not chosen to continue the study of mathematics to Grade 12. It was possible, in all but four cases, to sort out which section was applicable and so the data for the incorrect section was coded as missing.

4.6.2 Instrument 2 Introductory Activity: Survey on preknowledge and elicitation of suggestions for content and style of module

Description and pedagogical purpose.

The purpose of this activity carried out in 2003 and 2004, was to provide an opportunity for the students to interact with each other and to speak about the parts of mathematics that they had found difficult at school and that remained gaps in their knowledge, and to suggest topics to revisit. In addition, they could suggest sections of mathematics that might be useful in their daily lives and make suggestions for the teaching of the module in terms of teaching style and assessment activities. These were all free response questions.

Data generating activity.

The activity, done in small randomly assigned groups, was to complete an enlarged version of the question and answer sheet found in Appendix B.

Data reduction and analysis

A total of 28 groups completed the answer sheets, 11 in 2003 and 17 in 2004.The answers to the questions were typed into a table for subsequent analysis. A simple count was made of the topics suggested by the students as gaps in their knowledge and skills. In order to keep the number of topics manageable, where specific small sub-topics such as simultaneous equations were suggested, these were counted under the broader topic area of algebra. A similar procedure was followed for the topics suggested for revisiting, and for the sections of mathematics they envisaged being helpful in daily life. The suggestions for the teaching style of the MLE module were all similar and a simple count sufficed to capture the data.

Shortcomings and sources of error.

In 2004, there were twenty four repeat students who obviously knew the module content from their experience in 2003. Hence some of the suggestions for useful mathematics are clearly taken from their experience - this was verified by the names of group members on the original answer sheets. The mathematical topics suggested as gaps and for revisiting covered the whole range of school topics, with groups of preservice teachers in some cases seeming to mention all they could remember. This data was not therefore found to be useful.

4.6.3 <u>Instrument 3 Introductory Activity: Mathematics Bill of Rights</u>

Description and pedagogical purpose.

The data arose out of a second introductory class activity, based on a Math Anxiety Bill of Rights, created by Sandra Davis and described by Tobias (1993, p.226). This is a list of fourteen rights regarding mathematics learning, such as: I have the right to say I don't understand; I have the right to be treated as a competent adult. This was originally written to be used to allay students' mathematics avoidance, but it was used in this study as an activity to engage the preservice teachers with the rights as a first step towards taking charge of their mathematics learning and ceasing to be intimidated "both by their own lack of confidence and by hallowed traditions in the maths classroom that stop them feeling good about themselves" (Tobias, 1993, p.226).

Data generating activity.

The introductory small group activity reproduced in Appendix C, involved the preservice teachers in choosing eight of the rights, presented on slips of paper, and creating their own prioritised list of "rights" for mathematics learners. They were given the option of devising their own right to be used in preference to one of those given. The data from each small group was in the form of a poster.

Data reduction and analysis.

For my teaching purposes, a combined class charter of mathematical rights was constructed by counting the number of times each right was chosen. From this count, a hierarchical list could be drawn up, with the most popular choices heading the list. Subsequent data analysis involved assigning each "right" a value according to its position in the hierarchical lists from each small group (a score of 8 was given to the highest ranking right down to 1 for the lowest ranking in the list). This resulted in a score for each right, with a high score indicating that is was viewed as an important right. The hierarchical lists for each cohort were compared and scrutinized for trends. This data was used to indicate the overall attitudes of the preservice teachers towards learning mathematics, and to gain insight into their expectations at the outset of the MLE module.

4.6.4 Instrument 4 Mathematics Autobiographies: Maths and me

The research instrument and data analysis diagram, Figure 4.1, shows visually how this source of data forms the core of evidence to answer RQ1 of this study with the other instruments serving to provide signals towards promising codes and avenues of exploration.

Description and pedagogical purpose

For many years, together with colleagues, I had begun the initial Primary Mathematics Education module with an activity that involved eliciting preservice teachers memories of school mathematics which were written onto small slips of paper, and then burning the negative memories and preserving and displaying the positive memories. This was intended to symbolise a recognition of past experiences, but also an intention to make a new start. The MLE module was a new start with mathematics for many students who had not studied the subject formally for many years, or had a recent experience of failure in Grade 12 level mathematics and I decided to use more extensive written mathematical autobiographies as a way of acknowledging students' past experiences.

Autobiographies, both as a phenomenon and a source of data have been fully discussed in Chapter 3 (see section 3.3). A review of related research studies affirmed that the writing of their own mathematics story might be a helpful exercise for the preservice teachers in the MLE modules, and helpful for myself as teacher- researcher. The benefits for the writers include heightened self knowledge about their own mathematical learning, and reading the autobiographies enables the teacher - researcher to better empathise with the students, and to take them forward in their mathematical learning.

Data generating activity

If the writing is intended to promote reflection of mathematical experiences to date, it makes sense to give the assignment early to eliminate the influence of the course on the autobiographies (Ellsworth & Buss, 2000). Some researchers give many and detailed prompts; Ellsworth and Buss (2000) for example, report that they used twelve different prompts to elicit responses from students. These included questions such as: when you look at your education through a maths (or science) lens, what do you see?; what was your background?; who influenced you? and do you see places where your experience affected your life choices? (p. 356). Repsold (2002) asked students to include their most memorable moment, why they thought it important to study math, and something about their favourite math teacher and the qualities they possessed. Hauk (2005), in response to her research that indicated that recall of past experiences are more accurate among college graduates when a reward for accuracy is offered, and that current self-bias is reduced when deliberate memory search is prompted, used prompts and structure to facilitate reflective memory searching and awarded 10% of the course grade to this writing task. Students were required to write an essay of at least 1100 words, detailing twenty mathematical experiences with specific names and locations.

In this research study, the preservice teachers were given a page headed "Maths and me" (see Appendix D). It was explained that they should write the story of their experiences with mathematics to date, so that the last sentence should be "and now I am doing mathematical literacy". This was set as a take-away task to be returned by the next lecture. A token five marks was awarded for the completion of the activity and the return rate was high. All responses were photocopied and the copies filed for later analysis. In my teacher role, I read all the autobiographies and wrote a few sentences to the preservice teachers in response to what they had written, and returned the original responses.

Data reduction and analysis

The themes identified by eight authors in either their research studies specifically involving mathematics autobiographies, or from their work with mathematically anxious adult learners (see section 3.4), were placed in juxtaposition with themes evident from my preliminary data scanning to show points of commonality. The resultant table is found in Appendix U. From these themes, insights from the general literature review on factors influencing mathematical learning in section 3.4, a set of unifying ideas or themes was synthesised to provide a framework for the detailed analysis of my data. The themes were organised under the following headings:

Affective factors in mathematics learning
Beliefs about mathematics as a subject, its usefulness and inherent difficulty
Attitude aspects such as confidence, self-efficacy, and locus of control
Environmental factors impacting on mathematical experiences
Family, community and schooling factors
Critical incidents in the breakdown of mathematical learning
Memories of school mathematics

In addition to the more detailed themes discussed in section 3.4, Ellsworth and Buss (2000) found it useful to classify autobiographies in a general way, as positive, negative or transitional between the two. They regarded autobiographies which reflected a moderate to strong favourable student reaction to mathematics/science education experiences throughout the description as positive; autobiographies which reflected an indifferent to strong unfavourable student reaction to mathematics/science education experiences throughout the description as negative; and as negative to positive, or vice versa, autobiographies which reflected a definite transition in attitude from the beginning to the end of the description. Somewhat differently, Hauk (2005) classified the specific experiences described by the students in their autobiographies, rather than the overall story. Experiences considered to be hindrances to their interest in, or pleasure of mathematics were classified as negative. Examples were events and classroom atmospheres which occasioned fear, self-doubt, anxiety, unacceptable (to the student) levels of frustration, and in some instances physical pain. In contrast, experiences that she considered inspirational, good, or neutral, were classified as non-negative.

To ensure consistent coding, a table of inclusion rules was drawn up (see Table 4.2). This lists the code and sub-code names together with a description of the text that would be included in that code.

Table 4.2 Coding inclusion rules for analysis of student autobiographies

	Code	Description
Student belief about maths as a subject	Prosopopeia	Attribution of human qualities to objects or abstract notions
	usefulness/use for daily life	Maths is described either as useful for daily life, or as not useful for daily life
	usfulness as a ticket to work or study	Maths is described as gatekeeper to workplace opportunities, or to higher education. Door function
	Nature of maths Invisible maths	Maths that people do but which is not thought of as maths but more common sense.
	Nature of maths language and symbolism	Description of issues relating to the particular language and symbolism of mathematics.
	Nature of maths decision making	Description of need to decide on methods or strategies, or pressure to decide on answers quickly.
Environment al factors	family	Describes influence, positive or negative of family members on maths experiences
	school and community	Describes factors in the school and community that effected mathematics learning
	Teacher knowledge	teacher subject knowledge as an influence on maths learning
	Teacher professional behaviour	influence of professional or unprofessional behaviour of teacher on maths learning. For example, late coming, absenteeism, drunkeness
	Teacher attitude to learners	The influence of teacher attitude on maths teaching and learning. Example physical abuse, verbal abuse, low expectations
	teacher as facilitator	Describes teacher as empowering them to succeed.
	teacher as authority	Describes teacher as determining their success or failure, or being dominating in classroom
	Instructional strategies	Description of classroom practice in actually teaching maths
	Teacher saying	Verbatim quote of what the teacher said

	Code	Description
Personal factors	lack of ability	Students claims not have maths brain, or be clever enough
	lack of work	Student conceded that insufficient effort was made to master the work
	lack of confidence	distrust of intuition or self defeating talk
	attitude to the subject	Students indicates dislike/like of subject, or feelings about doing maths
Locus of control-	External	success or failure was due to environmental factors such as teachers, or poor school circumstances
	Internal	feel responsible for their own mathematics experiences
Critical incidents	Positive to negative transition	description of an incident or point when there was a transition in attitudes
	Negative to positive transition	
Memories	Negative memories	Experiences considered to be hindrances to their interest in, or pleasure of mathematics were classified as negative
	Non-negative memories	Experiences considered to be inspirational, good, or neutral, are classified as non-negative.

Shortcomings of mathematical autobiographies as research instruments.

Goodson and Sikes (2001) draw attention to the transient nature of the stories told by informants in life story research projects since "they are telling their story in a particular way for a particular purpose, guided by their understanding or conceptualisation of the particular situation they are involved in, the self/ identity /impression/ image they want to present, and their assessment of how hearers will respond" (p. 41).

It could be argued that when adults construct their mathematics autobiographies, current self view clouds the memory and past events are interpreted from an adult perspective. All life stories, by their very nature, are "already removed from life experiences: They are lives interpreted and made textual. They represent a partial, selective commentary on lived experience" (Goodson & Sikes, 2001, p.16). Furthermore, the process of telling about themselves, allows people to construct an identity and to add meanings and explanations to their actions in their retrospective narratives so that events seem more coherent and rational than may have been the case at the time (Convery, cited in Walford, 2001, p. 91). Hauk (2005), however, contends that whether or not the events described are real and accurately described is not the crucial issue as these personal memories "shape the way a person perceives experience, conceives the world, regulates cognitive and emotional responses, and interacts with others" (p. 39). What endures, is the student's perception and interpretation of past events, and so this is what is reported. Gibson and Costello (2000), in the context of student autobiographies that seem to indicate either a decision that mathematics is an unattractive subject, or that they had incompetent teachers, warn that the "stories may be a vehicle for external attribution of lack of success in mathematics rather than as a means of self-disclosure" (p. 38).

As discussed in the preceding section on data collection, the prompts provided to students prior to the writing activity differ from study to study. Interpretation and analysis of responses must take into account the prompts given. For example, if students were specifically prompted to identify their favourite mathematics teacher, the appearance of named teachers in the writing has a different significance to the appearance of named teachers in free response writing.

4.6.5 Instrument 5 Interim evaluation: How are you getting on?

Description and pedagogical purpose

After the experience of the 2003 module, a focus in 2004 was on personal responsibility for learning and a sense of self awareness regarding personal progress in mathematics learning. It was also thought that it could be beneficial to form some ability groups, possibly based on a self selection procedure. With this in mind, a simple questionnaire (see Appendix E) was devised. Students were asked to identify themselves with one of three positions: Managing well and needing only lecture time, battling a bit and needing the tutorials already provided, or not coping at all and needing extra help. In 2005, the questionnaire was extended and additional questions, designed to elicit information on classroom environment and use of the CD and book resources that were a new feature in this module, were added (see Appendix F). The style of this questionnaire was such that students chose the response, from a choice of either three or four alternatives, that best described their situation. For example, under the heading of language used in the lectures, they could choose from: I find the English used in the lectures easy to understand; I can understand the language if I concentrate; or I am battling to understand the language in the lectures. Space was left for any additional comments or clarifying remarks.

Data generating activity

About three weeks into the 2004 module, the students were asked to fill in the questionnaire in lecture time. The 2005 questionnaire was given after about five weeks, and after the first test had been written.

Data reduction and analysis

The responses were coded according to a detailed codebook, added to the master data spreadsheet and cleaned as described before. Any qualitative data deriving from the free response comments invited, was typed and added to the qualitative data set. The questionnaires were initially read by the researcher to obtain a sense of how the students felt they were getting on, and to see if there were problems that could easily and swiftly be acted upon. More detailed analysis followed later based on emerging themes in the data. The students' perceptions of how they were doing were correlated with their final module mark. The qualitative responses were coded for themes inherent in this data set, and for the themes and codes identified in the other qualitative data.

4.6.6 Instrument 6 Data test reflections

Description and pedagogical purpose

In 2003, having marked the data handling tests and seen a range of marks from 3% to 73%, as the teacher of the module, I was prompted to find out what was going on. Were the marks so poor due to lack of understanding, or had the students simply not put in the time and effort required to master the work? Did they know that their effort had been poor, or were they under the impression that what they had written was correct and sufficient to pass?

Data generating activity

In 2003, when the data handling tests were about to be handed out, each student was given a piece of paper and asked to write their responses to the questions on it. The questions were displayed on the overhead projector, and the contents of the slide are found in Appendix G. Once the tests were handed back, they answered the last questions. This was not done in 2004 as the tests were returned in the tutorial groups and so the opportunity was not there. In 2005 a more detailed questionnaire was put onto an answer sheet (see Appendix H) which was completed in the same lecture that the tests were returned.

Data reduction and analysis

The 2003 data was typed out at the time for qualitative coding along with the project data in NVivo. A detailed codebook was prepared for the 2005 version of the questionnaire which was much more structured and amenable to quantitative analysis. The 2003 data was revisited in an attempt to apply the 2005 codes. This was not successful as although two questions were similar, the phrasing of the questions was different. The responses in 2003 were more qualitative and descriptive and not easily put into simple numerical codes. For instance, several students said their test preparation was the time spent in tutorials which was difficult to quantify, and expressed disappointment over their test mark without clearly saying whether or not this mark was better or worse than expected. For these reasons, all the 2003 data was included in the NVivo project for qualitative analysis. The last four questions on the 2005 questionnaire were of the open response type. The responses to these were typed and included in the qualitative data corpus in the Research Question Three cluster.

The qualitative data was imported into the NVivo project and coded in the first instance according to the question it answered. The 2003 data was then printed out in questions so that themes could be manually identified and instances counted. The qualitative data for 2005 was treated in the same way, but it also served as confirming data for the findings of the more structured questions which were analysed quantitatively on SPSS. Graphical representations were produced to illustrate the data as appropriate.

Shortcomings and sources of error

The data available from 2003 and 2005 does not match neatly, and no data was collected in 2004 which disturbs the continuity of the data. In 2003, 59 preservice teachers provided data and in 2005, only 35 preservice teachers filled in the questionnaire. This is probably because in both cases, the data collection occurred at the very end of the semester and some students had abandoned hope, and lecture attendance was generally poor.

4.6.7 Instrument 7 Final course evaluations

Description and pedagogical purpose

It is a requirement of the university that each module lecturer provides an opportunity for the students to evaluate the module, and further that the lecturer takes cognizance of the results of these evaluations. In this case, the information from the evaluations was crucial in planning the next cycle of the module. In 2003, the course evaluation consisted of a biographical survey and initial questions as discussed in sub-section 3 above, and also open questions related to the various sections of the module. In 2004, the final course evaluation was prepared in conjunction with the Quality Promotion Unit (QPU) of the institution. This unit assists lecturers in compiling a list of questions to ask in a module evaluation questionnaires, analyses the results and prepares a report for the lecturer. This assistance is utilized by those seeking promotion on the basis of their teaching as well as those interested in researching their practice. For this study, in 2004 I selected and personalised (for example, by including my name in place of "the lecturer") a total of thirty seven items from the extensive bank of items provided by the QPU. These were organised under the headings of general, lectures, assessment, effort and motivation and tutorials. The students were asked to respond to each item on a five point Likert scale with a range of "strongly disagree" to "strongly agree." After each section, space was provided for any other comments on that section, and finally students were invited to write one or two sentences to describe their experiences in the MLE module. In 2005, an additional section consisting of nine items was added to evaluate the use of the additional resources provided, and one of the items relating to tutors was removed as it was no longer relevant. The 2005 version of the questionnaire is found in Appendix J.

Data generating activity

The module evaluation questionnaires were completed in one of the last lectures of each course as they were summative in nature. The questionnaires done under the auspices of the QPU were designed so that the responses to the Likert items were recorded on a Multiple Choice Question form for computer reading, and additional comments were written on the actual questionnaire. It is common practice internationally that such evaluations be unseen by the lecturer concerned until the module results are published - to the extent that they are kept in safety by the class representative until that date. In this case, the class representatives were asked to oversee the placing of the questionnaires and computer forms into a large pre-addressed envelope which was sealed in their presence and put in the internal mail to the QPU for analysis. The analysis was not available until well after the module results were finalized.

Data reduction and analysis

The Likert scale responses were coded from 1 for "strongly disagree" to 5 for "strongly agree." The QPU analysis combined scores of 1 and 2 into a category negative response, 3 a neutral response, and scores of 4 and 5 formed the positive response category. In addition to the relative frequency of each of the aforementioned categories, a mean score was computed. A mean of over 3 points to a positive response from the group overall, with all the usual caveats of outliers unduly influencing the means. In addition to the formal module report, the QPU provided the raw data in the form of the actual choices made by the students for each item, and also a typed version of all the comments. The data was extensive and so the use of exploratory factor analysis to reduce the data was investigated as described below.

Firstly, exploratory factor analysis was performed on the items from each section (for example, lectures or assessment) to see if components could be identified within each section, and the data reduced by the use of these new scales. This would provide a clearer picture of the preservice teachers' overall perceptions of the pedagogical practices employed in the module, as well as their perceptions of their learning behaviours, by possibly revealing latent variables. The Cronbach's alpha coefficient was computed to check the internal consistency of the items in each component. This is a measure of how well each individual item in a scale correlates with the sum of the remaining measures i.e. it measures consistency among individual items in a scale. Cronbach's alpha ranges in value from 0 to 1 - the higher the score the more reliable the scale. In addition to providing an overall measure of the internal consistency of the test items, this index identifies problem items that could be eliminated to improve the reliability of the scale.

The sample size for this part of my study (the 2004 and 2005 cohorts), is marginal for robust factor analysis, since especially with the exclusion of cases with missing data, the number of cases could fall short of the rule of thumb of "ten times as many participants as variables" (Field, 2005, p. 639) for some of the sections. There does not seem to be consensus on what score for Cronbach's alpha should be regarded as satisfactory and "no sacred level of acceptable or unacceptable level of alpha. In some cases, measures with (by conventional standards) low levels of alpha may still be useful" (Schmitt, 1996, p. 353). Field (2005) reports that while some people set 0.7 as an acceptable value for ability tests, "when dealing with psychological constructs, values even below 0.7 can, realistically be expected because of the diversity of the constructs being measured" (p. 668). Furthermore, the number of test items has a marked effect on the value of Cronbach's alpha, with large numbers of test items leading to higher values which may not necessarily be meaningful. Within the education literature, Bohlman and Pretorius (2002) studying aspects of reading skills, contend that "reliability scores of between 0.6 and 0.7 are regarded as satisfactory, while scores above 0.8 are regarded as desirable" (p. 201), while Lo and Lam (1998) reporting on a course evaluation questionnaire claim that "as all four scales have a alpha value greater than 0.5, the internal consistency reliabilities of the four scales are satisfactory" (p. 323).

The QPU analysis gave a percentage of students who had responded positively, negatively and neutrally to each item, and a mean score computed using the Likert scale values as rational scores. The raw data allowed me to conduct a finer analysis by considering the frequency of each response to the items and also to link the responses of the students to their other data.

Shortcomings and sources of error

Some of the students were unfamiliar with the process of recording their responses on a computer form and there were many questions in this regard which the tutors tried to answer. This compromised the confidentiality of the answers somewhat. Despite the assistance, there were several cases where the forms were incorrectly filled in with students marking several alternatives against a single question and leaving other questions blank or in one case circling the question number in each case. This resulted in a loss of data and raised a concern about the accuracy of the data captured by the computer analysis.

4.6.8 Instrument 8 Interviews

Description and pedagogical purpose.

The description of a research interview provided by Cannell and Kahn (cited in Radnor, 2001, p. 59), namely "a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information" captures the spirit and purpose of the interviews conducted in this study. Following Radnor (2001), interview schedules were designed to "elicit descriptive and explanatory information that presented a picture of the interviewee's interpretation of the situation under study" (p. 59). However, it must be recognized that "what is said will be co-constructed in that interview, and will be limited by perception, memory, evasions, self-deception and more on the part of both the interviewee and the interviewer, but that it can still have value" (Walford, 2001, p.97). At the very least, the interview will provide information on what the interviewee is prepared to say about a given topic in the social context, time and place of that particular interview, and this will add a strand to the rope of evidence. In practice, the interviews in this study followed the general pattern for qualitative interviews succinctly described by Kvale (1983): "It is neither a free conversation nor a highly structured questionnaire. It is carried through following an interview guide, which rather than containing exact questions focuses on certain themes. The interview is taped and transcribed word for word. The typed version together with the tape constitute the material for the subsequent interpretation of meaning" (p. 114). The context and particular circumstances pertaining to the interviews in this study are described below.

Data generating activity

The arrangement of the Faculty of Education calendar meant that both the university mid-year vacation and the five week teaching practice session intervened between the end of the MLE module and an opportunity to interview students. Once the second semester was underway, personalized invitations were prepared for each student and placed in their letter boxes. The invitations contained a tear off portion in which students were asked to provide a contact phone number and a commitment to come and make an appointment for an interview. In 2004, in an effort to personalize the interview invitations, four different invitations were used. These were for those with distinctions, those who had a straight pass, those who were repeating the course and those who had failed. Copies of these invitations are found in Appendices K, L, M, and N. A large lecture timetable was drawn up with the times available for interviews clearly indicated and students contacted by text message to come and choose a time. Each student was reminded of their appointment by text message on the morning of the interview. When the students arrived, some singly and some in pairs, they were welcomed and invited to sit down across a small desk from the interviewer. The purpose of the interview was explained and their anonymity assured. To reinforce this, students were asked to choose a pseudonym for my research use. Permission was asked, and in and all but one instance given, for the interview to be recorded on a digital voice recorder.

In 2003, the interview was very loosely structured with an invitation to talk about their experiences of mathematics from schooldays to date. In a similar study, Coben (2000) and her research team report using semi-structured interviews, in order to elicit the mathematical life histories of college students. They contend that "this technique enabled us to maintain points of comparison between interviews while engaging in open-ended, in-depth, one-to-one conversations" (p. 54). Cognisant of this, in 2004, the interviews were somewhat structured by handing the student a pile of cards, each containing a sentence beginning "Talk about….". (see Appendix O).These were spread out on the table so that the students could choose the ones they wanted to talk about, and work through them in the order they choose. The cards helped to collect equivalent information from all interviewees which facilitated the data analysis and gave the interviewee some sense of control over the direction of the interview and the reassurance that no surprise questions would be asked. The interviewees typically spoke freely and the interviewer attempted to listen without undue interruption. At the end of a topic, where appropriate, the interviewer condensed what was said and checked with the interviewee that this was a correct interpretation. This was a move towards a self-corrective interview with on the spot verification or falsification of the interviewer's interpretations (Kvale, 1983).

A total of thirty eight interviews with preservice teachers were conducted over the three years, mostly individually but occasionally in pairs. As Gaskell (2000) reminds us, "there are a limited number of interpretations or versions of reality" (p. 42) so that after a while the stories begin to be repeated, no new insights seem to be forthcoming and the point of meaning saturation has been reached. In this research project however, since it was considered important to give every student who volunteered the opportunity to be interviewed, the interviewing continued past the point of meaning saturation.

Data reduction and analysis

All interviews were transcribed and became part of the NVivo project as text and also in the voice file form. Linking the voice file to the transcription using the software made the voices of the interviewees easily accessible and served as reminder that "the transcription can give the impression of permanence to something that is inherently transitory" (Walford, 2001, p.95), and too much meaning can be vested in a phrase analysed apart from its context.

The responses to the invitation to talk about school experiences and mathematical experiences prior to the MLE module were analysed along with the mathematics autobiographies cluster as illustrated in Figure 4.1. The questions relating to experiences in the MLE module were coded in a cluster with the interim evaluation (Instrument 5), the data course test reflections (Instrument 6), the final course evaluations (Instrument 7) and the co-worker insights (Instrument 9) since these all informed the research question relating to enabling pedagogical practices (see Figure 4.1).

Shortcomings and sources of error

Several shortcomings and sources of error in using interviews can be identified. Since the interviews were voluntary, the interviewees are not necessarily representative of their cohort. Students who are shy or disaffected by the experience of the MLE module would be unlikely to come forward. As with the mathematical autobiographies, the caution issued by Jovchelovitch and Bauer (2000) needs to be kept in mind, namely that interviewers need to be sensitive to the fact that "the story they obtain is to some degree strategic communication, that is, it is a purposeful account either to please the interviewer, or to make a particular point within a complex political context" (p. 65). A real danger is to attribute to the people being studied the meanings we think they have, or we think we would have in the position we think they are in, instead of carefully asking them. This is not straightforward since the people we study often do not give stable or consistent meanings to things, people and events. Becker (1996) advises us to respect that confusion by not giving things a more stable meaning than the people involved do. We would do well to regard with some scepticism, long discussions and inferences drawn on passing remarks of people, or on data they have given in a hurry and off the top of their heads.

In 2004, despite personalised invitations on form letters, verbal invitations whenever I met the students in passing, and subsequent hand written letters, not a single repeat student (out of a possible thirteen) responded to the invitation to be interviewed. This was disappointing as they had almost all passed and would have been a valuable source of comparative feedback regarding the first two cycles of the module.

4.6.9 Instrument 9 Co-worker insights

Teaching and tutorial assistance was provided in each of the three years, and in each case both informal and written comment was obtained, but quite different in extent and style each year. In 2003, a short focus group interview was conducted with the five PGCE students who had been involved as tutors. This was recorded and transcribed and the answers to the prompts (as found in Appendix P) were subsequently summarised. In 2004, the four tutors employed were doing this tutoring as the practical component of a mathematics teacher education module. One of the requirements was that they lodged weekly reflective reports on their experiences in the tutorials. Permission was sought and obtained from these students to use their reflective writing as data in my research (see Appendix S).These reports were imported into the NVivo project and analysed qualitatively. In 2005, I was assisted in the module by a Masters student who was doing contract lecturing in another module, and two PGCE students who were principally employed to videotape the lectures and transfer the tapes to digital CDs, but having attended the lectures in that capacity were willing and able to tutor as needed. These three co-workers were asked to fill in a short questionnaire (see Appendix Q) giving their impressions of the pedagogical practices and learning behaviours evident in the module. This data was included in the data corpus in the NVivo project.

4.7 DATA COLLECTION METHODS AND FIELDWORK PRACTICE

The sample comprised all preservice teachers registered for, and completing the MLE module in 2003, 2004 and 2005. Students who dropped out of the module early on were excluded from the sample as their data was incomplete. Students who repeated the module were treated as new cases in the subsequent year of study, but were given the same pseudonym each time so that their voices can be identified throughout this study.

4.7.1 Ethics and power relationships in the research

The first power issue is that of a possible power differential between the researcher and the leader or instigator of a larger research project. Breen (2003) correctly remarks that most teacher reflective research is undertaken as part of initiatives by outside agencies and reported by academics. In such research projects, it is usually the university researcher who has the funds and human and physical resources necessary to drive the research process and hence the power lies with the designer of the study rather than the teachers involved. In this research study, the researcher is both the teacher and the university researcher with access to funding, so the power rested squarely on the researcher in terms of research design and implementation.

The second power issue is, however, very pertinent to this study. Cameron, Frazer, Harvey, Rampton, and Richardson (1994) remind us that being researched is potentially exploitative and damaging to the subjects, and despite rhetoric around mutual participation, in the main research is done on subjects. We are further cautioned that "even when you do not work for a government agency, and whatever your own political views, it is always necessary to think long and hard about the uses to which findings might be put, or the effects they may have contrary to the interests of subjects" (p. 18). For example, McNiff and Whitehead (2006) urge researchers to consider whether they would be prepared to become whistle-blowers if their research revealed irregularities or abuses. Once the findings are published they can be used in ways over which the researcher has no control. For example, in this study, the participants shared stories of very dysfunctional schooling and unprofessional teacher behaviour which was clearly more prevalent in African schools. Reporting this lays certain groups open to criticism and shame in a way that is not an intention of reporting the study.

Labov (cited in Cameron, Frazer, Harvey, Rampton, & Richardson, 1994) suggests two principles of social responsibility for linguistic researchers which we can apply more generally: (a) the principle of error correction and (b) the principle of debt incurred These principles imply firstly that it is the responsibility of the researcher to make efforts to correct erroneous views people may have of something, and secondly, that the community whose participation has enabled the research community to gain some new knowledge is subsequently owed the use of that knowledge to their benefit if the need arises. Consequently the researcher should adopt an advocacy position, characterised by a commitment "not just to do research on subjects, but research on and for subjects" (Cameron, Frazer, Harvey, Rampton, & Richardson, 1994, p. 20). It cannot be taken for granted that what a researcher advocates is in fact what those researched want or need. In this study, I was strongly influenced by my stance on social justice and my professional judgement as a teacher and mathematics educator and sought to advocate accordingly. It is nevertheless undeniable that the above mentioned influences were my personal versions of social justice and professional judgement.

Ethical research demands respect and this is well described by Bassey (1999) who identifies three aspects of respect. Firstly, there is respect for democracy which he explains as the freedom of the researcher to ask questions, express ideas, make critical observations and publish research findings. Secondly, there is respect for truth which implies not only that researchers are expected to be truthful in data collection, analysis and reporting of findings, but that the onus is on the researcher to avoid both intentional deceit and the unintentional deceit that may result from sloppy work. Thirdly, there is respect for the persons participating in the study which necessitates recognition of the participants' initial ownership of the data and respect for their dignity and privacy. Ethical considerations clearly indicate that the participants need to fully informed about the implications of their participation in the study before their consent is sought. The process of obtaining informed consent from the preservice teachers in this study is described below.

4.7.2 Informed consent:

About midway through the module, the purpose of the research was explained to the students and they were asked for their consent to use their work for academic research purposes. The timing of this was deliberate as it was felt that asking for consent ahead of any knowledge of the teacher or the module work, as would have been the case if the informed consent was sought at the outset of the module, would not be fair. The institutional guidelines for this informed consent altered slightly over the three years, and every effort was made to follow the ethical guidelines. For example in 2005, in accordance with the new guideline that participants be given an opportunity to consult their families and others prior to giving consent, the students were shown the consent form during the lecture period and the implications discussed. They were invited to think about it and individual consent forms were handed out during a test period a few days later (see Appendix R). The forms were collected and filed and the data set on students who did not sign a form was discarded. The student tutors who worked closely with the researcher in 2004 and journalled their experiences also signed a consent form agreeing to allow to the use of their reflective writing as a source of data (see Appendix S). All these students were at least eighteen years of age and so no parental permission was required.

4.7.3 Trustworthiness

Drawing on the work of Lincoln and Guba, Bassey (1999) lays down eight criteria for trustworthiness. These are considered more appropriate for case study research than the ideas of reliability and validity which are more suited to quantitative statistical studies involving cause and effect issues.

1. Prolonged engagement with the data sources sufficient to be immersed in the issues and build the trust of participants.
2. Persistent observation of emerging issues. This involves focusing on salient features that seem important to check for relevance and importance
3. Raw data adequately checked with sources
4. Sufficient triangulation of data leading to analytical statements
5. Working hypothesis, evaluation or emerging story been systematically checked against the analytical statements
6. Critical friend tried to challenge the findings
7. Account of research is sufficiently detailed to give the reader confidence in the findings
8. Case record provides an adequate audit trail

These steps are all evident in this study, apart from number six, as only informal discussions on the emerging findings were held with colleagues and co-workers.

4.8 SUMMARY

The reader is referred back to the organising frameworks provided in Table 4.1 and Figure 4.1 which also serve to provide a summary of the instruments used in this study, a brief synopsis of the data obtained from that instrument, the research question (RQ) it is primarily informing, and finally the method of analysis employed.

Research Question One

What is the nature and strength of the productive disposition strand of mathematical proficiency evident in preservice teachers entering a Mathematical Literacy module.

Research Question Two

How is the productive disposition strand of mathematical proficiency of preservice teachers changed after completion of the Mathematical Literacy module?

Research Question Three

What pedagogical practices and learning behaviours best enable preservice teachers to develop Mathematical Literacy?

Four instruments were used in order to address RQ1; a pre-module questionnaire, an introductory Bill of Rights class activity, mathematical autobiographies and interviews. The quantitative data analysis from the questionnaire generated codes to look for in the qualitative data, both in the questionnaire and in the mathematics autobiographies and the interviews. These codes were largely the result of factor analysis. This approach served both to triangulate the data, and to deepen the qualitative data analysis by alerting the researcher to themes and codes to look for. RQ2 and RQ3 were informed by the data collection described below. At the outset of the module, preservice teachers were given the opportunity to indicate their preferred style of teaching which serves to provide initial information about the pedagogical practices that they think would best enable them to learn mathematics. As the module unfolded, the preservice teachers were given further opportunities to write about how they were getting on, and what learning behaviours they were employing (Instruments 5, 6 and 7). Key indicators for best pedagogic practice and successful learning styles included performance in tests and examinations, student feedback on the module teaching, take-up of help provided – tutorials, CDs borrowed, books in library, and lecturer/tutor insights. The quest was to identify the enabling factors that allowed preservice teachers to pass while others of seemingly similar ability failed. The insights of my co-workers provided a semi-outsider perspective on the teaching and learning in the module.

In the following chapter, I start the presentation of the data with the mathematical stories of the preservice teachers entering the MLE module, and provide an overview of the productive disposition of the students. The subsequent chapter is a three part story of the unfolding of the module over its initial three years.

CHAPTER 5

IN MY BEGINNING IS MY END

"In my beginning is my end" T.S. Eliot, Four Quartets, East Coker, Line 1.

In this chapter, I describe the beginning - the mathematical stories of 254 preservice teachers as they enter the MLE module, since it is my contention that these beginnings have a profound effect on the end, in this case the success in the MLE module. The initial productive dispositions of the preservice teachers entering the MLE module are investigated by a combination of quantitative and qualitative methods which support each other. The findings are summarised in the form of three fictional letters. The core data on the dispositions of the preservice teachers towards mathematics was obtained from written autobiographies and interviews. The theoretical framework for the analysis of this data is the result of a review of the literature, iterative data coding and the interplay between quantitative exploratory factor analysis and the qualitative analysis. Such careful analysis is crucial, since as Basit (2003) reminds us, while raw data may make interesting reading "they do not help the reader to understand the social world under scrutiny, and the way the participants view it, unless such data have been systematically analysed to illuminate an existent situation" (p. 144). The initial part of this chapter lays out the themes emerging from each of the instruments as these pointed to codes for the detailed analysis of the core data. In conclusion, the data is synthesised in answer to Research Question One: What is the nature and strength of the productive disposition strand of mathematical proficiency evident in preservice teachers entering a Mathematical Literacy module? Or in other words, to what extent do they perceive mathematics as useful and worthwhile, see themselves as effective learners and doers of mathematics, and believe it is worth the effort?

5.1 INSIGHTS FROM INSTRUMENT ONE; PRE-MODULE QUESTIONNAIRE

The initial module questionnaire contained four questions relating to school experience of mathematics.

1. Which words best describe your experience of school mathematics?
2. What affected your ability to do mathematics?

3. What were the reasons you gave up mathematics before Grade 12 level?
4. What were the reasons you continued with mathematics to Grade 12 level?

The data arising from each of these questions was analysed in turn, and the results reported in the ensuing sections. These results provided insights into the productive disposition of the preservice teachers as they entered the MLE module.

5.1.1 Which words best describe your experience of school mathematics?

The preservice teachers were asked to select two words from a list of ten (see Appendix A). Some preservice teachers chose only one word and others left the question out, so in the end a total of 440 choices were made. The results presented graphically in Figure 5.1 are counts of the number of respondents who selected each word.

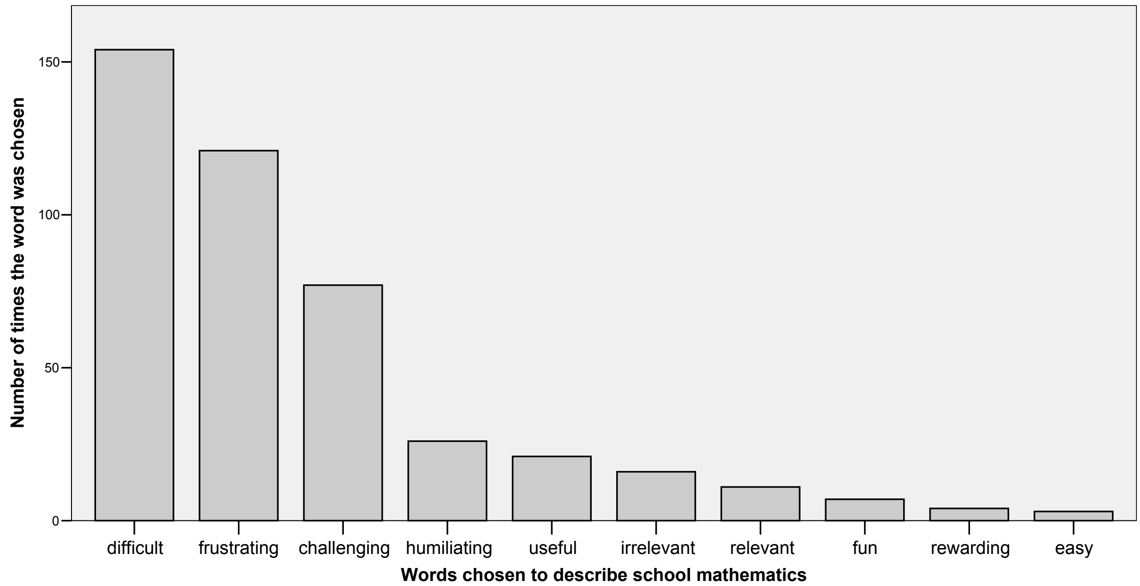


Figure 5.1. Frequency of words chosen to describe school mathematics

What is immediately striking is that three words dominate, namely difficult, frustrating and challenging. The "positive" words, (useful, relevant, fun, rewarding, and easy) occupy five of the six last places and account for only 12% of the choices. The pattern of responses was very similar for both genders and only minor variations were noted when the data was disaggregated according to race, type of school attended and school mathematics background.

In addition to selecting words, the students were asked to write a sentence describing their school mathematics experience. These sentences were imported into NVivo and coded at each of the suggested words. Inclusion rules were drawn up to assist in coding consistently in cases where the actual word was not explicitly mentioned in the text. As the coding proceeded, a new theme of "confusing" became evident and this was added. While on the one hand, some sentences were coded at several nodes since they fitted under each description or included several of the given words, on the other hand, about 25 sentences could only be described as generally positive or negative, for example, *I would rather have had shock therapy than attend a maths lesson* (Brian, 2005) and so were not included in the classification table.

Table 5.1 Inclusion rules and coding analysis of sentences describing school mathematics

Node	Inclusion rule and illustrative example	Sentences coded at node
frustrating	Mentions tried but failed, unable to understand, not taught well or some impediment to success. e.g. *I did not understand Maths no matter how hard I tried.*	90
difficult	Mentions the difficulty in any section. e.g. *It was the most difficult subject and I used to fail each and every test including examinations.*	50
challenging	Mentions requiring effort, hard work or practice e.g. *I think mathematics is very challenging because it requires a lot of practice so you can understand it.*	38
confusing	Can't decide on formula, understand or make sense of the work. e.g. *I can't catch up fast and I can't understand what is happening. And I fail to do the correct formulas evertime (sic).*	18
humiliating	Mentions an incident of ridicule or embarrassment, or disrespectful behaviour. e.g. *When I got to high school my teachers just discoursed(sic) me. They would make jokes about my marks instead of helping me.*	17
useful relevant	Mentions value of mathematics for life or career or another subject. e.g. *Mathematics was very useful to me. It encouraged me to think critically.*	8
easy	Mentions a section that was easy, or understandable. e.g. *Maths was easy and tests was not difficult but the exams was nightmare*.	8
fun	Cites a pleasant mathematics lesson or experience. e.g. *My experience in school mathematics was fun though maths was difficult*.	7
irrelevant	Indicates that mathematics is not needed for their career, or daily life. e.g. *I still do not understand why we done math in high school because I have never been to a job or a college where they require you to solve maths problems.*	6
rewarding	Mentions affirmation of any kind e.g. *Didn't find it really difficult, but had no interest in it, was rewarding at times to solve problems.*	2

Table 5.1 provides a list of the nodes used, the inclusion rule for each node, an illustrative example of a sentence coded at that node and the total number of sentences coded at that

node. The rows of the tables are arranged in order of the frequency of the occurrence of each node.

The rank order of the words chosen by the preservice teachers and represented in Figure 5.1 is strikingly similar to the rank order resulting from the coding of the sentences, with "difficult", "frustrating" and "challenging" occupying the top three positions in both cases. The top ranking of "frustrating" in the sentence analysis is probably due to my interpretation of the word as implying an impediment to success, being broader than might have been assumed by the preservice teachers. For this reason, a sentence describing an incompetent teacher would have been coded as a frustrating school experience by the researcher but may not have led the preservice teacher to choose frustrating from the list of words. It is conceded that the consideration of a list of words that might describe school experience of mathematics immediately prior to composing a sentence on the same topic, may have led preservice teachers to use those words in their sentences. Be that as it may, most of the words used were embedded in sentences, for example, *my school maths was* *humiliating* *as I said above, if you never knew the answer you were laughed at which immediately gave me a negative attitude towards maths*, indicating that the words were aptly chosen and indicative of the preservices teachers' feelings and experiences. Both the quantitative analysis of the words chosen to describe experiences of school mathematics, and the qualitative analysis of sentences written on the same topic lead to the same assertion: The preservice teachers enter the MLE module with a school mathematics history that they describe as difficult, frustrating and challenging.

Almost all of the preservice teachers in the MLE module have been unsuccessful in mathematics at some time in their schooling, and cannot fail to have noticed that other learners did better than them. This leads to the question of attribution of success or failure, probed by asking about the factors the preservice teachers in this study thought influenced their mathematical ability.

5.1.2 What affected your ability to do mathematics?

Ten possible influences were presented (see Appendix A) and the preservice teachers indicated the strength of each influence on their ability to do mathematics. Initial analysis utilising means, indicated that no factor reached a mean close to a strong influence, and the differences between factors was not easy to interpret. Exploratory factor analysis was used to extract components to make the analysis clearer. Initial analysis indicated two components and so a rotation was performed to generate a pattern matrix from which a table of factors loading onto each component was generated. (The process of exploratory factor analysis is fully described in section 6.2.2. in the context of the module evaluation questionnaire). Suffice to say here that two components were identified resulting in the sub-scales presented below, together with the associated values of Cronbach's alpha, and the items contributing to each scale:

Schooling scale. (Cronbach's alpha = 0.74)

The way I am taught
The personality of my teachers
How much mathematics my teachers know
The course materials I am given
How much work I do on my own
My previous mathematics experience

Self scale. (Cronbach's alpha = 0.57)

How clever I was born
My ability to think logically
My parents' maths ability

The items loading onto Component One, which accounted for 33% of the variance in the data, are all related to teaching and learning and were combined to form a new scale named **Schooling**. Component Two which accounted for 16% of the variance in the data, contained items related to innate ability to do mathematics and were combined to form a new scale named **Self.** These are very close to the causal attributions of effort and luck or helpful others, and the casual attribution of own ability described by Tobias (1993) and Meyer and Koehler (1990) and discussed in the context of gender differences in section 3.4.4. The factor analysis met the criteria outlined by Miller, Acton and Fullerton (2002) for good factor analysis, namely that all variables load on only one factor and are low on all other factors, and that the results should be consistent with theory or common sense. The items in each scale were conflated and the mean score on each scale was computed. The maximum possible value of the mean was 4 (a very strong influence) and the minimum possible\value was 0 (no influence at all). The mean score on the Schooling scale was 2,2 which indicated a more than moderate influence of schooling factors on perceived ability to do mathematics, and the mean score on the Self scale was 1,5 which is midway between slight and moderate influence on perceived ability to do mathematics.

Using the 5% level of significance, the ANOVA table (see Appendix V) showed that race was a significant grouping variable for the Schooling scale with p=0.038. This indicates that the differences in means between the identified race groups is statistically significant at the 5% level of significance, or in other words, with 95% certainty, we reject that there is no difference between means of race groups. We thus conclude that there is a difference in scores between race groups and we are 95% sure that we have drawn the correct conclusion. However, when examining each pair of races to see where the difference lies, using the Scheffe test, we find that this test does not indicate a significant difference between any two race groups. This simply means that the Sheffe test is not sensitive enough to pick up where the difference lies. A contributing problem could possibly be due to the unequal sizes of the racial groupings, or the great variation within each grouping. It is however noticed that the Scheffe test indicates a "near significant difference" between the mean scores of the White and African students on the Schooling scale, with the Whites students according this factor a greater influence on their ability to do mathematics.

Similar ANOVA testing on the Self scale indicated significant differences in the perception of the influence of this factor on students' ability to do mathematics between the groupings according to gender, race and school mathematics background (see Appendix V). The male students ascribed more influence to this factor than female students, the Asian students ascribed more influence to this factor than did any other race group, but only statistically significantly more than the African students, and those who had studied mathematics to Grade 12 level ascribed more influence to Self factors than those who had terminated their study of mathematics at Grade 9 level. The gender difference noted here is consistent with the research discussed in section 3.4.4. which indicates that boys are more likely to attribute their success to their own ability, a sentiment captured by the Self factor. The other differences are possibly idiosyncratic, although the public perception is that the Asian community accords high status to mathematics and this might partly explain why the Asian students attribute success to innate ability to a greater degree than other race groups.

The preservice teachers entering the MLE module indicated their schooling as having a moderate influence on their mathematical ability, and their innate personal attributes as having only a slight influence, seeming to be tending towards an external locus of control (Mearns, 2005).

5.1.3 <u>What were the reasons you gave up mathematics before Grade 12 level?</u>

Useful insights can be gained into a person's disposition towards mathematics by considering the choice they made at Grade 9 level regarding the continuation or termination of mathematics study, and more pertinently, the reasons underlying that choice. This section deals with the analysis of the data relating to the reasons given for not continuing with mathematics.

The preservice teachers who had discontinued mathematics before Grade 12 (n=168) were asked to rate nine suggested reasons for this choice, on a five point Likert scale (see Appendix A). Exploratory factor analysis on the data revealed three components. The items forming each sub-scale are shown below, together with their associated Cronbach's alpha value. One of the items, related to the influence of friends, did not load sufficiently onto any scale and was not included in the subsequent analysis.

Dispiritment scale. (Cronbach's alpha = 0.67)

My teachers discouraged me from doing mathematics
I was getting bad marks for Maths
I didn't like the Maths teacher
I didn't like the subject

Compulsion scale. (Cronbach's alpha = 0.54)

My parents didn't think I should take mathematics
I had no choice as Maths was not offered at my school

Irrelevance scale. (Cronbach's alpha = 0.59)

I did not think it would be useful for daily living
I didn't think Maths was required for my career choice

The reasons falling under each component seem sensible in the research context and were named as shown above. The first component, was named Dispiritment as it comprised the reasons characterised by discouragement and lack of enthusiasm. The second component, named Compulsion, contained two items that suggested that the decision to discontinue maths was out of the hands of the preservice teacher. Finally the third component was named Irrelevance as the items both suggested that mathematics was considered unnecessary.

It is clear from Figure 5.2 that the Dispiriting factors were perceived as the most compelling reason for discontinuing mathematics before Grade 12, although with a somewhat less than moderate influence. One way ANOVA testing between the groupings gender, race, type of school attended and school mathematics background revealed no statistically significant differences between the groupings for the Irrelevance and

Compulsion scales, but race and type of school attended were significant grouping variables for the Dispiritment scale (see Appendix V). White students and those attending ex Model C schools indicated that Dispiriting factors had a moderate to strong influence on their decision not to continue with mathematics (mean=2.58 and mean=2.38 respectively) whereas African students and those attending poorly resourced schools indicated that Dispiriting factors had a less than moderate influence on their decision not to continue with mathematics (mean=1.68 and mean=1.58 respectively).

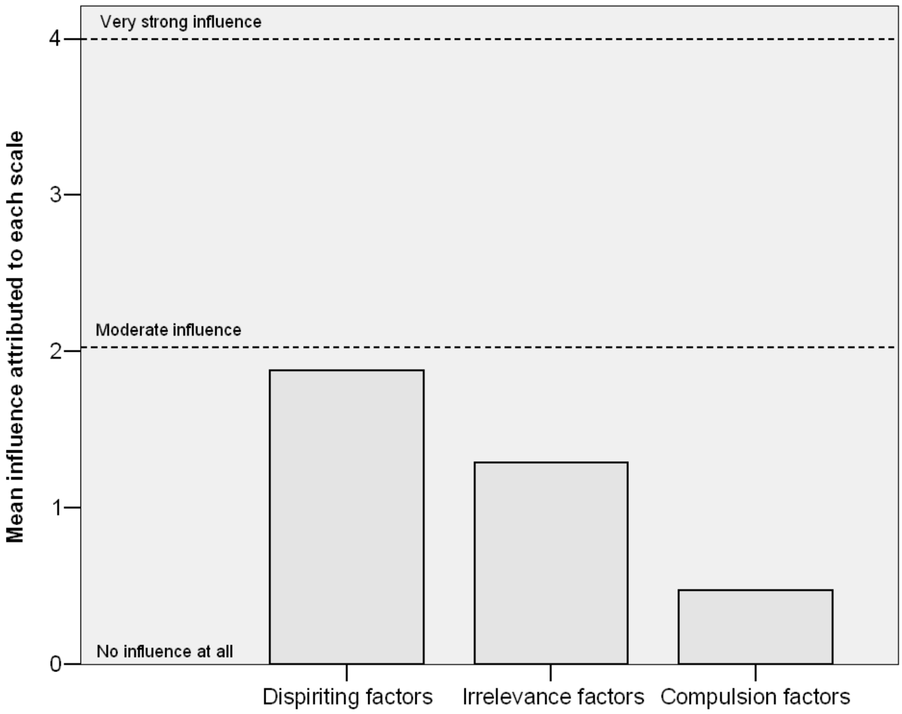


Figure 5.2 Mean influence on decision not to continue the study of mathematics to Grade 12

5.1.4 <u>What were the reasons you continued to study mathematics to Grade 12 level?</u>

A total of 93 preservice teachers in this study indicated that they had studied mathematics to Grade 12 level, and they were asked to rate possible reasons for this choice on a five point Likert scale (see Appendix A). Although the reasons suggested for continuing with mathematics were matched to the reasons for not continuing, the exploratory factor analysis yielded different sub-scales. The three sub-scales in this case, with their component items, and associated Cronbach's alpha values are shown below.

Affirmation scale. (Cronbach's alpha = 0.62)

I wanted to be in the class with the clever students
I was getting good marks for Maths
My teachers encouraged me to do Maths

Affinity scale. (Cronbach's alpha = 0.61)

I have a love of the subject
I liked the Maths teacher

Obligation scale. (Cronbach's alpha = 0.61)

I had no other choices
I thought it would lead to better job opportunities
I thought it would be useful for daily living
My parents thought I should take mathematics

The first component which accounted for 32% of the variance in the data was named Affirmation since the reasons loading onto that component were of an encouraging nature. The second component accounting for 16% of the variance in the data contained reasons related to liking the subject and the teacher and was named Affinity. The third factor accounting for 12% of the variance contained the reasons related to feeling compelled to choose mathematics and hence was named Obligation. Although the item "I had no other choices" loaded onto the latter component, the internal consistency of the scale was much improved if it was deleted, and so this item was not included in subsequent analysis and computation of means.

Mean scores for each sub-scale were computed by combining the items under each scale. Figure 5.3 shows that the mean score for the Obligation factor is the highest with a slightly over moderate influence, and the mean scores for the other two factors indicate that both the Affinity and Affirmation factors were perceived to have a slight to moderate influence on the decisions of the students to continue with mathematics to Grade 12.

One way ANOVA testing showed that race was a significant grouping variable ($p=0.00$) for the Affinity factor. Further comparison of means revealed that this factor was deemed by African students to have a slight to moderate influence on their decision to continue with mathematics (mean=1.88), whereas White students indicated only a slight influence (mean=0.67) and the Coloured students even less influence (mean=0.39). This is consistent with the findings of TIMSS 2003, that in general, the attitudes of South African learners, the vast majority of whom are African, indicated that they enjoy and value mathematics and science (Reddy, 2006b). Reddy cautions that we "must consider that these may be socially desirable responses, and one would have to probe further to determine the 'real' attitudes of the learners" (p. 95).

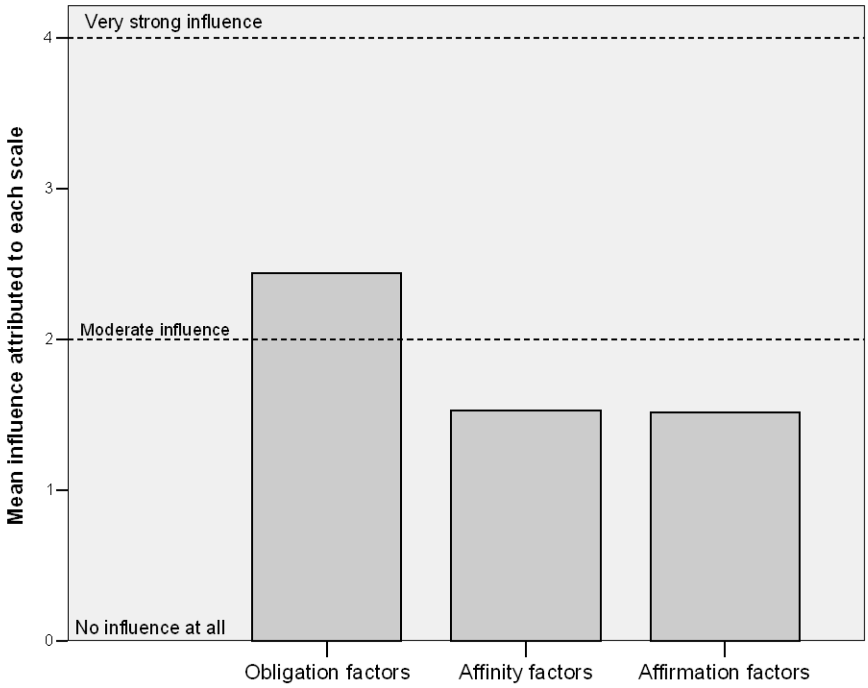


Figure 5.3 Mean influence on decision to continue study of mathematics to Grade 12 level

Race was also a significant grouping factor in the Affirmation scale (p=0.04) but a subsequent Scheffe test failed to indicate a significant difference between any racial grouping pair. Scrutiny of the means reveals that the Coloured students (n=5) indicated that Affirmation factors had a moderate to strong influence on their decision to continue with mathematics whereas White students (n=6) indicated a much lower influence for Affirmation factors (mean=0.72). The number of students falling into each of these racial categories is however too small for us to make any generalisations.

In conclusion, the data from the initial questionnaire indicated that the preservice teachers entering the MLE module perceived school mathematics to be difficult, frustrating and challenging. They perceived their schooling to have had the greatest influence on their mathematical ability, with the dispiritment consequent on poor performance and teaching being the strongest influence on their decision to discontinue mathematics before Grade 12 level. Those preservice teachers who did continue the study of mathematics to Grade 12, did so largely due to a sense of obligation.

5.2 INSIGHTS FROM INSTRUMENT TWO: PREKNOWLEDGE SURVEY AND SUGGESTIONS FOR TEACHING STYLES ACTIVITY

The data from Instrument Two (see Appendix B) consisted of questionnaires filled in by eleven small groups (about five students) in 2003, and seventeen small groups in 2004. When asked to identify gaps in their mathematical knowledge and skills, and topics to revisit, many of the small groups seemed to suggest all the topics they could remember from times tables to calculus. Several groups wrote *everything* or *everything except addition and subtraction, multiplication and division.*

When asked to suggest preferred teaching styles and methods of assessment, several groups made multiple suggestions, yielding a total of 36 suggestions. There were 17 suggestions for small groups, and a further six for a combined whole class/small group style, making learning in small groups the most popular choice. Three groups mentioned that the tests should not be done under time pressure and there was one suggestion of oral tests.

In summary, the preservice teachers entering the MLE module perceive many gaps in their mathematical knowledge and seemed reluctant to claim knowledge of any section of school mathematics. Small group instruction, at least alongside whole class teaching, was by far the preferred teaching style.

5.3 INSIGHTS FROM INSTRUMENT THREE: THE BILL OF RIGHTS ACTIVITY

The rights identified and ranked by small groups of preservice teachers (see section 4.6.3) showed a very consistent order over the three years as evident in Table.5.2. The top position achieved by the right concerned with learning at an individual pace and not being made to feel put down or stupid when this individual pace is slower than the rest of the class is indicative of a group of hurt and anxious learners used to lagging behind. This right, and the right to feel good about oneself regardless of abilities in maths, were clear front runners in the overall score. These were consistently near the top in all three cohorts. The right not to understand maths, was scored extremely low by all cohorts and did not feature on any group's list of top eight rights.

Table 5.2 Top eight rights forming a mathematics Bill of Rights, as identified by three cohorts

Ranking 2003	Ranking 2004	Ranking 2005
I have the right to learn at my own pace and not feel put down or stupid if I'm slower than someone else.	I have the right to learn at my own pace and not feel put down or stupid if I'm slower than someone else.	I have the right to learn at my own pace and not feel put down or stupid if I'm slower than someone else.
I have the right to need extra help.	I have the right to feel good about myself regardless of my abilities in maths.	I have the right to feel good about myself regardless of my abilities in maths.
I have the right to ask whatever questions I have.	I have the right to ask whatever questions I have.	I have the right to ask the teacher for help.
I have the right to ask the teacher for help.	I have the right to ask the teacher for help.	I have the right to say I don't understand.
I have the right to say I don't understand.	I have the right to say I don't understand.	I have the right to ask whatever questions I have.
I have the right to feel good about myself regardless of my abilities in maths.	I have the right to need extra help.	I have the right to evaluate my math instructors and how they teach. *
I have the right to view myself as capable of learning maths.	I have the right to view myself as capable of learning maths.	I have the right to be treated as a competent adult.*
I have the right to feel relaxed when doing maths.	I have the right to feel relaxed when doing maths.	I have the right to feel relaxed when doing maths.

Note. Rights indicated with * do not occur in the other lists

5.4 INSIGHTS FROM INSTRUMENTS SEVEN AND EIGHT - THE MATHEMATICS AUTOBIOGRAPHIES AND INTERVIEWS

Three overarching themes emerged from preliminary reading of the mathematics autobiographies and the results obtained in the instruments discussed above. These were similar to those found in the literature and in descriptions of similar studies. The themes are (a) beliefs about mathematics as a subject, (b) environmental and personal factors impacting on mathematical experiences, and (c) the breakdown of mathematical learning. Refer to section 4.6.4 and Table 4.2 for a detailed list of the themes and coding inclusion rules. In summary, following Bassey (1999), three fictional pieces are presented to capture the essence of the stories of the 254 preservice teachers who participated in this study.

All student quotes in this section are presented in italics and labelled with the pseudonym of the preservice teacher and their cohort year. The quotes are from the written mathematics autobiographies unless otherwise indicated.

5.4.1 Beliefs about mathematics as a subject

Three themes were identified under this heading, prosopopeia, the usefulness of mathematics and beliefs about the nature of mathematics. These are discussed in turn.

Prosopopeia

This theme, meaning the attribution of human qualities to objects or abstract notions, was evident in my initial analysis of my data where for example, students gave mathematics an almost human nature and referred to the subject as an enemy or friend, or as being strong, and was consequently identified as a theme for the more detailed analysis. Overall 37 instances in mathematical autobiographies and interviews were identified where preservice teachers ascribed human, animal or chemical characteristics to the abstract notion of the subject mathematics. Technically, only the former would qualify as instances of prosopopeia but the others are included as they indicate that for the person, mathematics seems almost a separate physical entity. The disjoint nature of the learner and the mathematics is made clear by the following two descriptions: *Maths and me it's a water and paraffin* (S'fiso, 2003) and *Maths and me is like oil and water* (Kahjal, 2004).

Mathematics was occasionally described metaphorically as an animal, as an elusive rat (Sindi, 2003), and as an annoying mosquito buzzing in an ear (Wayne, 2003). More fanciful descriptions included a monster under the bed (Kathryn, 2003) or a ghost coming back to haunt the person (Madeline, 2005; Fatima, 2005). Two other preservice teachers alluded to the idea that mathematics seemed to be following them, no matter how they tried to run away. The following excerpt from an interview illustrates this: *You know when I was filling this form, they said I must do Maths Literacy, eish! I was very worried, I was like 'Oh this thing I've tried to go away with it it's still following me now'* (Siwe, 2004).

More common though, was the portrayal of mathematics as a person with whom a relationship could be formed. Mathematics was usually perceived as being in an adversarial relationship with the person. Sometimes the person described themselves as trying to be friends but being rebuffed for example, *Well, I liked maths very much but maths didn't like me at all* (Smangele, 2004)and *Mathematics and me are me two things which are dwell together but completely different. I had tried it a lot to be by my side and being a friend but Maths couldn't take a notice of what I've been tried to do instead it kicked me away with both feet, Algebra & Geometry* (Msawenkosi, 2004). Similar bitterness is evident when a preservice teacher wrote that *what Maths did to me I will never forget* and added *thanks to Maths I am still the first year student, Maths and me will never get along anymore* (Musa, 2003). Finally Colin's story of a battle with mathematics exemplifies this theme of personification.

Many many moons ago in the valley unknown a little boy named Colin would be going to school for the first time. He was so excited and eager to learn but he did not know that this was the beginning of a thirteen year struggle against a mathematic hell. It was a new mathematical system that would give Colin nightmares in the deep dark night. The mathematic system eluded him. He was taught to calculate in a card format and the way of the soldier sum. He never understood the concept of the quantive (sic) value of a number. Then came the crippling blow that would forever be a mental scar for him. He sat at a white claustrophobic cubical where he stared blankly at a mathematical test. It laughed at him, it made him feel like a fool. Thus it resulted in him shedding tear and think this happened to him in the first two years of his school career. The next five years mathematic hide its ugly face as it did it damage in his. Mathematics raised its head once again but in two forms. The first was the new mathematics teacher and secondly the class he was in. The new mathematics teacher did not know how to control his students. Thus the class took advantage, therefore mathematics got another upper hand on Colin. The next year Colin would get his own back. As a mathematic wizard known as Mr. B would help him conquer his fear. Unfortunately the wizard had to retire. Colin soon had to leave that school and was moved to a rural school. Here would be the final show down between Colin and his eternal enemy mathematics. Mathematics beat him down and down until Colin fell. His body bent and spent he said pantingly "You win, I quit". But now it is the return of Colin and he will be victorious against his mathematic enemy (Colin, 2005).

Usefulness

The theme of usefulness or relevance has two aspects in this context. Mathematics was described as either useful, or not useful for daily life, and as a gatekeeper to access work or study opportunities. This code is linked to the Irrelevance scale identified as an influence on the decision to discontinue mathematics and the Obligation scale identified as an influence on the decision to continue with mathematics (see sections 5.1.3 and 5.1.4). Twenty eight passages were coded at the theme of usefulness for daily life. Two preservice teachers who had workplace experience prior to entering university had different experiences to relate. Brian, a mature student, who had remarked that he *would rather have had shock therapy than attend a school mathematics lesson* (Premodule questionnaire, 2005) wrote of how well he managed in the workplace: *I am fairly competent with basic maths functions and I used to be very involved with Bookmaker business in the UK. Before this business was computerized in the last 3 years, all settling, accounting etc was done manually. This meant that I had to work quickly with figures* (Brian, 2005). In contrast, Tshengisile related an experience that underscored the purpose of the MLE module, namely to produce teachers who can cope with the quantitative demands of the profession. *Last year I was employed as a substitute educator. I worked till school closed for summer vacations. In that period I was forced to do calculations for year marks. That was a hard period in my life because I was not used in calculations. In those calculations I came up with the more than one hundred percent. My principal advised me in studying maths literacy and computer literacy in my degree* (2005).

Some of the preservice teachers indicated in their autobiographies that they appreciated the need for at least some mathematics to cope with the demands of life and work and particularly as teachers. As Kwanda wrote *it is very important for teachers. It is absolutely does not sound good that a teacher cannot do measurements, cannot read graphs, cannot give proper percentage where necessary* (2003). Other preservice teachers did not perceive the need for any further mathematics, nor indeed, mathematics at all. Wayne wondered why we need maths *to prove what, to impress my mates or impress myself* (2003), and Lizelle wrote of her three years spent working in London where she never needed maths as she had a calculator to hand and her *life was perfect without maths* (2004).

Thirty two passages were coded at the theme of mathematics as a gatekeeper to workplace opportunities, or a door into higher education. Some of the preservice teachers terminated their study of mathematics because it was not seen as useful for their future careers, for example in drama, and Thelemusa (2004), explained that *maths was kicked out* because he needed to do a subject that he had some reasonable chance of passing on higher grade in order to get the exemption needed to study law. The majority in this category however, made what they now consider to be bad decisions, because so many bursary opportunities and jobs are only available to those with good mathematics marks in the matriculation examination. The following account by Sizwe illustrates the regret felt when it turns out that mathematics is required for jobs, and people find themselves disqualified due the fact that they do not Grade 12 mathematics. *When I was still growing up, my friends used to compete on counting numbers and multiplication tables. I was not part of it because I hated everything to do with maths. I even went to primary school with that perception of disliking maths which led me to failing the subject….Grade nine was the last class for me with Maths. I became spiritually free. The problem started when I got the employment with a good offer. The problem is they wanted someone with Matric but did not say the specified subject. I didn't survive on that job because it had most of the time to do with counting and balancing things. That is when I realised the importance of having a maths. I had to leave the job in favour of someone suitable for that position and would do better that I did. My friends who used to compete on tables are now doing well in tertiary institutions because they chose the right channel since their childhood* (2003).

The role of mathematics as a gatekeeper was questioned by Siphamandla (2003) who, after noting that advertisements for trainees in the newspaper often specify mathematics, remarked that *I always find it difficult to understand that why always maths, maths because I know how to count money*. In an interview, Leon (2004) suggested that mathematics is required by tertiary institutions on the premise that you need it to think logically but observed that *you can think logically without having high marks in Maths.*

Nature of maths

The "nature of mathematics" theme encompasses the sub-themes of "invisible mathematics", "language and symbolism of mathematics", "decision making in mathematics" and finally the "status of mathematics".

In their autobiographies, and in interviews, some preservice teachers commented on the particular nature of mathematics either directly, or by implication. The first sub-theme was "invisible maths" - a term suggested by Coben (2000) to describe the mathematics that people do but which they dismiss as common sense. This sub-theme did not turn out to be a feature of this study as it was used in only three instances. It was a marginal decision to assign this sub-theme as a code as the preservice teachers were identifying some everyday mathematics that they could do (for example Siphamandla's comment above that he could count money) but did not seem to be counted in deciding their mathematical ability. Rather flippantly, Adrian claimed that although not *the best of maths students, I was still good* *enough to realise my position on a rugby or hockey field and know that 12 seconds on the 100 m was pretty styling (sic) for a guy my age* (2004).

The second sub-theme considered was that of language and symbolism in mathematics. This concerned the particular notation and language of the subject and not issues related to the language of instruction which are discussed later. Four students alluded to the confusing nature of the digits and signs, well captured by the comments *the maths work became different and strange* (Jackie, 2003), and *I found this utterly confusing, believing that you cannot add, subtract, multiply or divide letters of the alphabet* (Suzette, 2004).

The third sub-theme related to the decision making aspect of mathematics which is characterised by a description of the uncertainty that arises in selecting correct procedure, often under pressure of time and examination conditions. This occurred in six instances, chiefly in descriptions of the confusion in trying independently to decide on a correct method. For example, Lungile claimed that *there were so many formulas that I have to use in order to solve a problem and I didn't know which formula must I use in order to solve that problem. Mathematics was the most difficult and challenging subject I have ever done in my entire life* (2004).

Finally, the status-conferring nature of mathematics was identified as a sub-theme. Students explained that in schools more status is given to the classes who take mathematics as a subject, and often those who do the so-called general subjects feel disparaged. Lindane, a very articulate student and a high achiever in History and English, spoke at length in the interview about the frustration at being overlooked for prizes at school, which he perceived to be a consequence of not being in the mathematics class. He concluded by saying *so, I had more negativity towards Maths, because first of all, besides the fact that it was the subject that inflicted pain upon me for a number of years, it was now the subject that was going to block me from getting the top five in the grade and to feel equal to other students…. It is a high status subject. They held them at the helm, rather than us students who did general subjects. So, we were just left out in the cold. Now you can imagine, being left out in the cold because we don't do Maths, the kind of attitude we are going to have towards the subject* (2004). Siwe spoke in the interview of the loss of status he suffered due to his poor mathematics performance and reported that *most of the people they used to say 'ay you don't know Maths you are not a person, you are not important', you know all those things* (2004).

5.4.2 Environmental and personal factors impacting on mathematical experiences.

Most preservice teachers in this study gave a narrative account of their school experience of mathematics, often with explanatory notes as to who and what influenced their mathematical experiences. The influential people or features in the person's environment, included as sub-themes in the framework for coding (see Table 4.2), were firstly the family members, secondly the wider community including the institution of the school, and thirdly the teacher. Finally, the factors related to the preservice teachers themselves, such as their self-perceived ability, efforts and achievements in mathematics were coded as sub-themes under the broader theme of personal factors impacting on mathematical experiences.

Family

In all, thirty passages were coded to this theme, twenty of which mention family members as playing a supportive role in their mathematics experience. Seven preservice teachers related stories of their parents introducing them to mathematical ideas by, for example buying them an abacus (Seema, 2003; Urmilla, 2003), teaching nursery rhymes and poems about numbers which *contributed to my better performance in mathematics in my early school days* (Pule, 2004), showing grouping and operations with small stones (Alile, 2003), or using everyday events such as shopping or dividing fruit to talk about mathematics (Iris, 2003; Hloni, 2004). Hloni also related how his mother introduced him to counting, explaining that *she taught me to count using my fingers. After knowing how to count it was then easy for me to count numbers of sheep as I was a herdboy, even when playing marbles*.

Three preservice teachers spoke of the aspirations their families had for their future careers, which led them to strongly encourage and advise perseverance with mathematics. Interestingly, this advice was not taken in any of the cases. *When I was young my mother use to told me to do Maths at school. The reason that make my mother told me to do maths at school because Maths got lot of opportunities when I finished at school. Maths got opportunities such as working on stores and banks etc. I didn't take my mother advise cause I thought she doesn't know what is talking about by that time* (Faye, 2004).

Two preservice teachers had relatives who were mathematics teachers who could provide help, and others had siblings who could assist or be role models. In contrast, Ephraim wrote of how the negative attitude of his older brothers and sisters demotivated him as they told him *maths is so difficult you will find out when you are doing Grade 10*

(2003), and Shirley had little support from her parents who *refused to send me to extra maths lessons and just said if I can't do it, why bother* (2004). In some cases, the parents were not themselves educated and as Phyllis recalled that she *did not get help and advice from them about subjects, it was up to me what I think is good for me* (2004). In addition to family influences, as described here, there were a range of factors in the school structure and community which had an impact on the mathematical experiences of the preservice teachers.

School and Community

Twelve preservice teachers told of how they were excluded from studying mathematics past the Grade 9 level by the circumstances in the school. Sometimes this was the school policy that those with poor mathematics marks were put into the general stream which seemed to be accepted, but in other cases it seemed more capricious and led to resentment. This is exemplified by Kwanda's story written in his autobiography. *Then my teachers took me to do general subjects and I asked why? They told me, they can not have me in maths as well as my brother too. Well I complain about it but it never work. Since then I told myself that maths is no longer my subject. I gave it up and make sure that I do not even think about it. That is why I am blank today, because it was stolen from me* (2003).

Other preservice teachers, for example Daniel (2005), and Olwethu, quoted below, reported the same problem of full classes as they applied late for registration at high school: *My high school principal gave me no choice when he said "If you don't want to take history that means you can't be a student for this school in this year because maths class which you want is very full. I have only a place in history class". I forced and bound myself to drop my lovely maths under that circumstances* (2004).

Two of the more mature students wrote of their schooling in the pre-democracy days. Verna who was 42 when she did the MLE module described the platoon system in operation at some schools, and the effect that had on her mathematics experience: *Firstly the classrooms of our school were very few so we have got to have two sessions of attending classes which is in the morning and afternoon classes. I was attending in the afternoon we are already tired and we are placed in a class we can not even concentrate from Maths teacher who is always having problem of failing to control us. He will talk faster in a low voice. The only student who will hear is those who stays in front, sometimes not. That is how I got a problem of Maths* (2004). Sele, who was 31 at the time, pointed out that she could not take advantage of the extra lessons after school since *if you are hungry you can't stay after school for extra exercises and practice* (2004).

Another schooling problem frequently mentioned was the seeming succession of teachers at rural schools where for example, Stabiso reported that *in Grade 12 I was confused because we had five different teachers who had never taught us before* (2004) and Khululile described how *during the same year the subject teacher changes, and she comes with the different explanations compare to the last one, and once we get to understand that one he was changed again in the very same year. So it was the hell of the year* (2004). Bathebile had to go to another school on Saturdays as there was no mathematics teacher at her school (2004). Perhaps the toll of a disadvantaged rural education is best expressed by Joy's story, told in her autobiography: *I was in a rural area school and so we has a shortage of teacher, sometime the teacher could not come to school for the whole week since she was pregnant. It made it difficult for me because I was not also good at maths. And the changing of teachers really disturb my attention at school and we ended up doing maths with our neighbour school and we were more than 100 in one class which make it difficult for the slow learner like me to concentrate properly and pass my tests* (2005).

A lack of resources featured in just two stories with Zenzele writing that *it was very difficult for me to study it because the equipment at school was insufficient for us as learners to study it* (2005). One preservice teacher expressed the opinion that female teachers were better and noted that *everything started to change … because our teacher was a male teache*r (Sylvia, 2003) and there was a single instance of mention of racism when Vuyisile wrote that he *got a racism educator with poor educating in maths, he only depends to the members who are good in math*s (2004). It is however, not really clear how the racist behaviour was manifested, nor why the fact that the teacher was male was seen as problematic. More specific comments on the teachers are discussed below, beginning with the reported influence of the teachers' mathematics subject knowledge on the mathematical experiences of the preservice teachers in this study.

Teacher knowledge

Comments about teacher knowledge in this context, typically fall into two categories - they know too much or they know too little. There were fifteen passages coded under teacher knowledge, four related to teachers who knew too much, ten related to incompetent teachers and there was one general comment that *the Mathematics teacher must be of good quality. So they will produce a good quality of student with Maths*

(Madoda, 2004). A teacher who knew too much caused problems because *he was not good in explaining it because to him maths was very easy and it seems like to everybody it was clear* (Nomusa, 2003), or *he was too fast for us* (Bongs, 2004). Four preservice teachers reported how they had been allocated teachers with little expertise in mathematics teaching, and in whom they had little confidence. Leon (2004), for example, described his Grade 8 teacher who was a rugby coach and sports. teacher and who, in his opinion *didn't know much more than we did* and then in the subsequent year a teacher who was a woodwork teacher and a rugby coach *who used to ask some of the students for the correct answers, not just to test their knowledge, but because he himself didn't know the answers*.

Some students, for example Goodman, described mathematics teachers who did not seem to have the subject content knowledge required to teach Grade 12 higher grade mathematics and resorted to using standard grade materials. This resulted in Goodman experiencing *a lot of problems when I was sitting down writing the exam Math paper one and two* and consequently not obtaining an exemption (2004). Similarly, Sele (2004) in an interview spoke of the discouragement she felt when it became evident in tests and examinations that the theorems and proofs offered by the teacher had been incorrect.

Teacher: professional behaviour

A total of thirty two passages referring to the influence of professional or unprofessional behaviour of the teacher on mathematics learning were identified. Sixteen related to physical abuse ranging from throwing chalk to beatings, seven to verbal abuse, three to being drunk at school, and the remainder to various forms of dereliction and self-serving behaviour.

The following four extracts from mathematics autobiographies illustrate that the reported incidents of physical abuse occur from the first year of school through to the senior grades. *As a growing young boy of six, I began to find myself facing problems with regard to understanding mathematics, the problem was far worse when I now lived in fear of getting the constant slashing with a cane because of my failure to understand this subject. I therefore developed a hate for the subject and this contributed tremendously to my atrocious performance in mathematics* (Lindane, 2004).

I remember the time when I was at standard two at that time there was no grades. When the Maths teacher came in to the class she wants us to have the tin tips or little stones that we were going to use for counting. One day when she came into the class she asks for this tin tips from each one of us. Unfortunately mine were not with me. I had lost them. There it started the problem. She told me to come in front of the class. When I was *there she gave me three sums of multiplication. One of these sums was 7 x 1. then I didn't give her the correct answer for that sum. The next thing she did I was punished in a way that my hands became swollen that I can't even wash myself. I started there to hate Maths up to now* (Thembi, 2003*).*

The problem doesn't stand still because at Grade 7 and 8 the teachers who used to teach maths were Mr No-nonsense they always carrying a cane whenever they came to the classrooms and their teaching system was good to those who were good on Maths but for us (knew nothing) it was terrible, because we were the food of the cane (daily bread). As a result we ended wearing 2 or 3 trousers or a lot of T-shirts to make sure that whenever they starts their magic we are ready for themselves!!! What happened on grade 9 was more humiliating, devastating and shamefully because the teacher puts me under pressure. She always wants to show off what a fool I was in front of the class (Msawenkosi, 2004).

When I began high school things started to change. I had seven subjects to do and school was a bit far from home, that meant I had to travel to school and back home. In spite of everything I chose Maths as one of my subjects from Grade 8 to 10. The teacher as such had no mercy and I was impatient with him. As learners, we were supposed to be at school an hour before school start, to do what he called Maths extra class. The teacher never ceased to use 'corporal' punishment! And that time it was 'allowed'. I never failed his work but I failed to be on time for the morning class and was punished severely for that (Goodness, 2004).

Verbal abuse typically accompanied the physical abuse and was also described as being a reason for the dislike of mathematics. Zaheera relates how she did her homework everyday and tried her hardest but *this just was not enough because she still humiliated me in front of my whole class and then the entire school. She laughed at me and called me stupid, clumsy and idiot, dumb and useless, so I just gave in and stopped working at maths altogether and let the hate totally consume me* (2004). Sizwe spoke in the interview of the deep sense of injustice he harbours as the result of the actions of a teacher in his schooldays: *But I think that it is not that I don't like Maths…Maybe the teachers were not that good to make me feel comfortable in Mathematics. Let me give you an example. I remember one day we were doing equations and he gave us thirty Mathematics things to do. So I did twenty-nine and the thirtieth one I forgot to complete. I left it halfway. When I got into the class, he asked for his homework and I gave it to him. You cannot believe when he found that I did not complete the thirtieth. He called me before the class and he gave me seven on my hand and just imagine that, he did not even appreciate what I did. Just* *punished me for the only small mistake I made…. That is why I decided to quit Mathematics…. It was a mistake and maybe in some years to come when I meet that teacher I will tell him that he did not deserve to teach Mathematics.*

Dereliction in the form of neglect of the responsibility to adequately prepare learners for the examinations was mentioned in the previous section in relation to teachers' inadequate expertise in teaching mathematics, but was also evident in the neglect of the assessment responsibility of teaching as in the case described by Nelisiwe. *When I was at high school my teacher for Maths does not mark our work she always came and say write exercise A up to E and after that she put her signature she did not mark and see where is your problem. Even if we are writing a test we don't know that we are correct because any at time she didn't mark even a test and the end we fail* (2004). In a similar vein, Sanette recounted that she *loved going to the maths class because we had fun there. When we wrote tests we got high marks but in the exams we done horrible (sic). Well, that was because the teacher was there for tests and helped us out, but in the exams we were lost* (2004).

Other teachers seemed to be absent from their classrooms leaving their learners to fend for themselves. The reason for the absence was sometimes known, for example, Iris had a *money loving* teacher who used to leave them *in the dark for his tuck shop to sell during breaks* (2003), and Andrea relates the account of her mathematics teacher who was hardly ever there but *when he did come and teach us he taught for a few minutes and then his cell phone would ring and then we all would get side-tracked* (2003). Others only reported that the teachers ignored them and were lazy and seldom in class, seeming to be there simply for the money and not for any sense of dedication to the pupils (Mmeli, 2004: Benisanani, interview and mathematics autobiography, 2004). In three instances, mention was made of the teacher being drunk. In personal interviews both Bongs (2004) and Benisanani (2004) revealed that they had secondary school teachers who were frequently appeared drunk in the classroom, and Sebenzile wrote that in Grades 8 and 9 the mathematics teacher *drank and smoked during the lessons so not much was done during those periods* (2003).

Teacher attitude to learners

The unprofessional attitudes towards the learners, although frequently mentioned, were not universal and there was evidence, discussed below, of teachers playing facilitating roles as well as authoritative roles. Following Ellsworth and Buss (2000), the data was coded for the preservice teachers' perceptions of their teachers as facilitators empowering them to succeed or as authority figures determining their success or failure.

In all of the autobiographies and interviews, numbering over three hundred in total, only eleven passages were identified as indicating that the teacher was perceived as a facilitator for mathematics learning. The following extract from an autobiography is one such example. *There was once a female teacher, who taught us very well from grade 8 up to 9. She uses to come to every desk solving students problem and giving them plans how to practice maths when they are free. She did not care when or how you call her when you need help with your sums. In the middle of the year in grade 11, she told us that she is going to get a transfer to another school. There was only one problem with me, I understood her than any other teachers who came and did maths in my class. She never uses cane to punish when you have mistakes instead she calls you to explain your problem.* (Cinnie, 2004)

Sadly, in the cases of Zaheera and Pule, the facilitating teacher is described as coming too late to avert failure as described in the following extracts: *But in grade 11 and 12 I had a wonderful maths teacher that I disappointed so very much by failing her subject and no matter how hard I tried the 3 years of abuse was just too much for my fragile psyche to have handled* (Zaheera, 2004) and; *however when I was doing matric final I found a good teacher that I can never forget. He was really a teacher not a cheater. He taught in such a way that all learners could understand and gain all the concepts, unfortunately it was too late that I got someone like him. So I failed my matric mathematics* (Pule, 2004). Nevertheless, their last memory of school mathematics was good which augured well for future study of mathematics.

Unfortunately, many preservice teachers spoke only of authoritarian teachers who were perceived to control their success or failure. All of the examples of physical and verbal abuse discussed above are indicative of an authoritarian teacher disempowering learners. More insidious though, are examples of belittling the pupils and undermining self confidence. For instance, Khela describes how the *teacher who taught maths in our school would always look down on us who didn't understand maths and she also used to make nasty comments about us and by so doing she made our hopes of becoming mathematicians some day disappear rapidly* (2003). Nomthandazo remembered being told that "*Maths was for the people who are clever*" and being discouraged from doing it further (2004) and Pule recalled his teachers *telling me how idiotic I was and that I was not fit to be in their class* (2004).

Teacher instructional strategies

After all the mention of the teachers' attitudes and influences on mathematical learning, we come to the business of teaching, in particular the instructional strategies remembered from their school days by the preservice teachers in this study. While relatively few preservice teachers mentioned the content of the mathematics, particular styles of teaching did feature, most commonly the practice of calling on learners to publicly attempt mathematical problems. Boredom was mentioned by four different preservice teachers, ascribed to the style of teaching. *When I was young I hated Math, just because it was a difficult subject for me and I felt it was also boring. We would do Math for the whole hour and I'd feel like screaming, just sit there and wait till the lesson ends, especially when it had a double periods. Every single day an hour of Maths I'd feel like saying "Get out you stupid teachers". I'd stutter and say um…um..um..um..all the way when asked to give an answer* (Nontokozo, 2004). The teachers' responses to questions and requests for explanations were also cause for comment. Iris wrote of asking the teacher how to get to the final step of a problem and *the only answer we could get was look at step 1, step 2 and 3 and you will see the answer* (2004), Khululiwe's inexperienced teacher responded to questions by saying *it is now your homework to find that answer* (2004), and when Mary and her classmates had a *misunderstanding and asked her about something concerning maths she was use to say none of her business, work on your own* (2005).

Several mathematical autobiographies and interview accounts contained mention of the perceived negative attitude teachers had towards those who were not doing well in mathematics and how such learners were sidelined in the classroom. For example, Leon spoke of his teacher who was *only worried about the people who achieved the higher marks and he basically said those of you who are doing well sit at the front and those of you who are not doing well sit at the back because I am not worried about you* (2004). The memories seem to be very persistent and details of words the teachers used are recalled many years on.

What my teacher said to me

Figure 5.4 to 5.6 are composite representations of what the preservice teachers recall their teachers saying to them. These have been divided into dismissals when approached for help (Figure 5.4), attempts to discourage learners form continuing with mathematics (Figure 5.5) and exhortations to greater efforts (Figure 5.6).

All of the following comments and memories of school mathematics appear to have been related to factors external to the actual learner, and mostly indicate an external locus of control. The explanation for success or failure in mathematics was given in terms of community, school or teacher influences. This corresponds with the Schooling factor identified from the exploratory factor analysis of the questionnaire data, and which was found on average, to be perceived as having a slightly more than moderate influence on the preservice teachers ability to do mathematics.

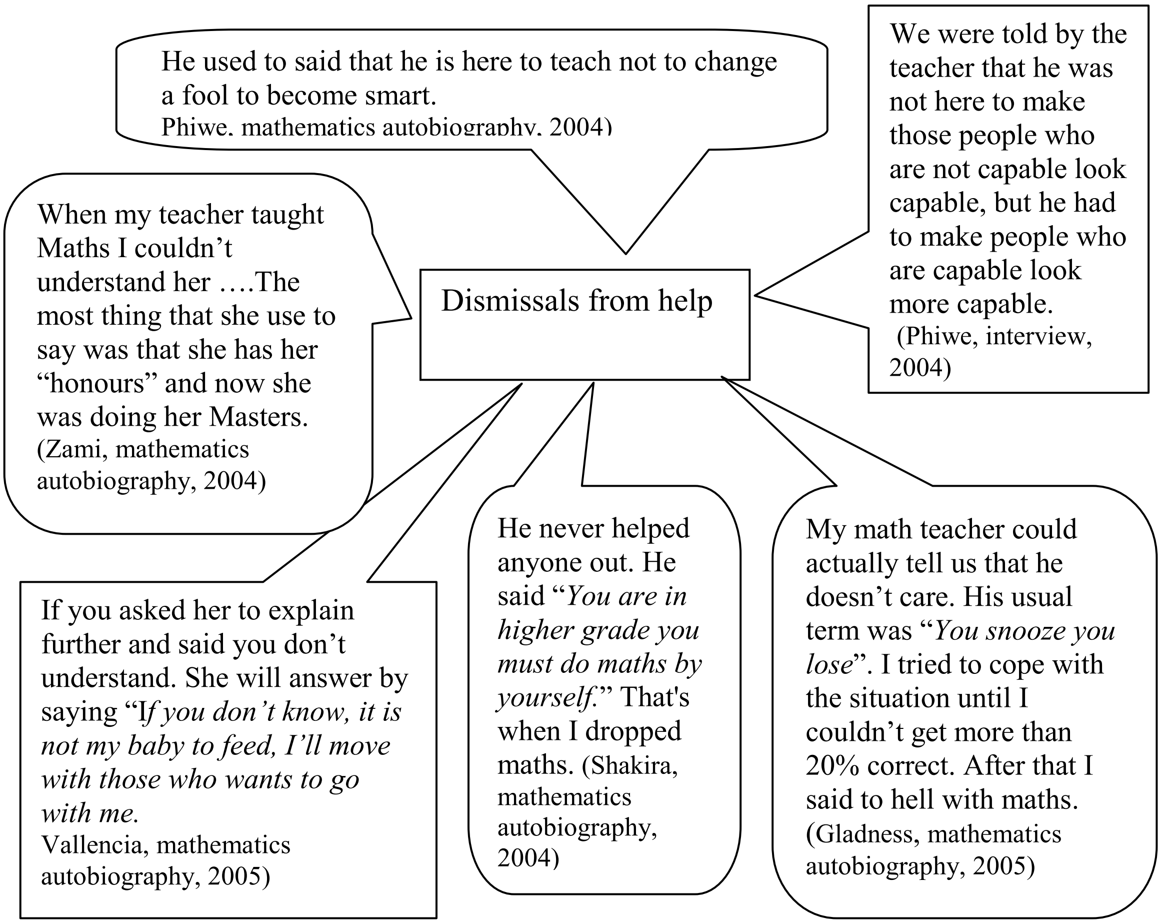


Figure 5.4. Things my teacher said to me - Dismissals

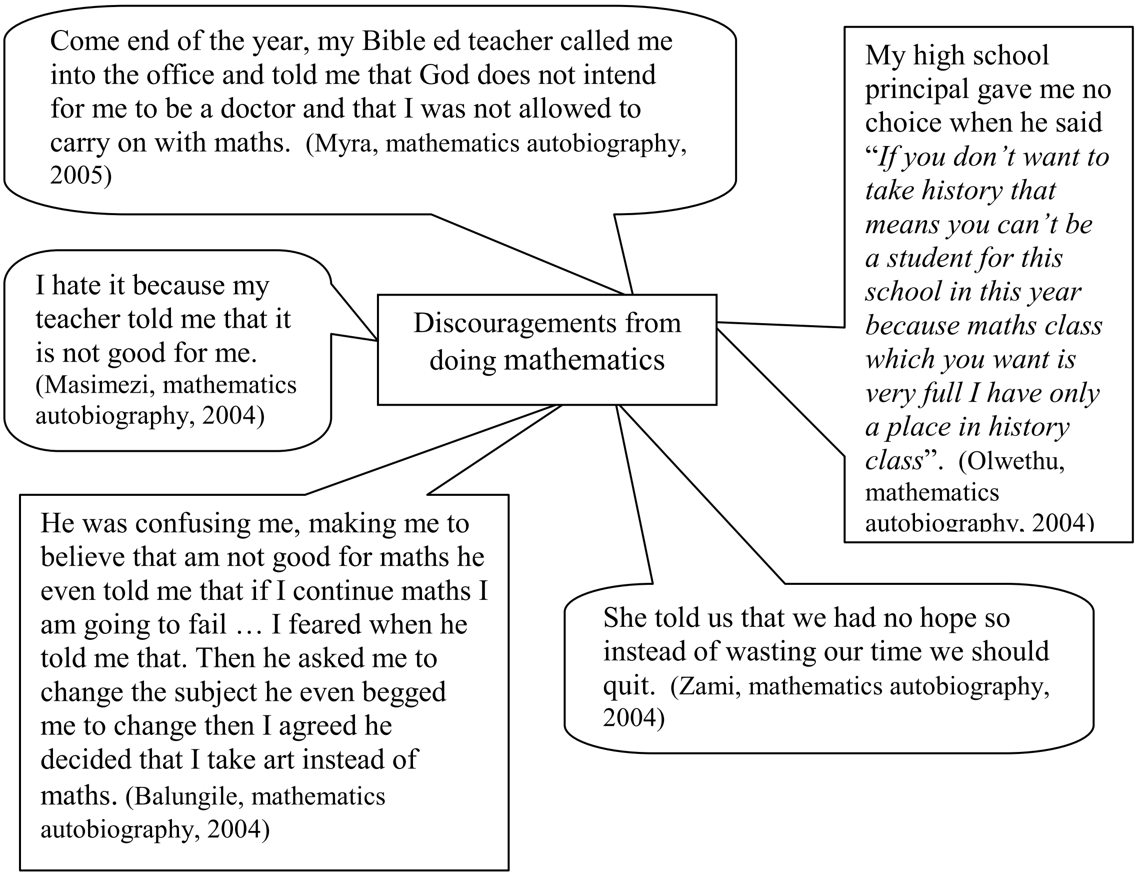


Figure 5.5. Things my teacher said to me - Discouragements

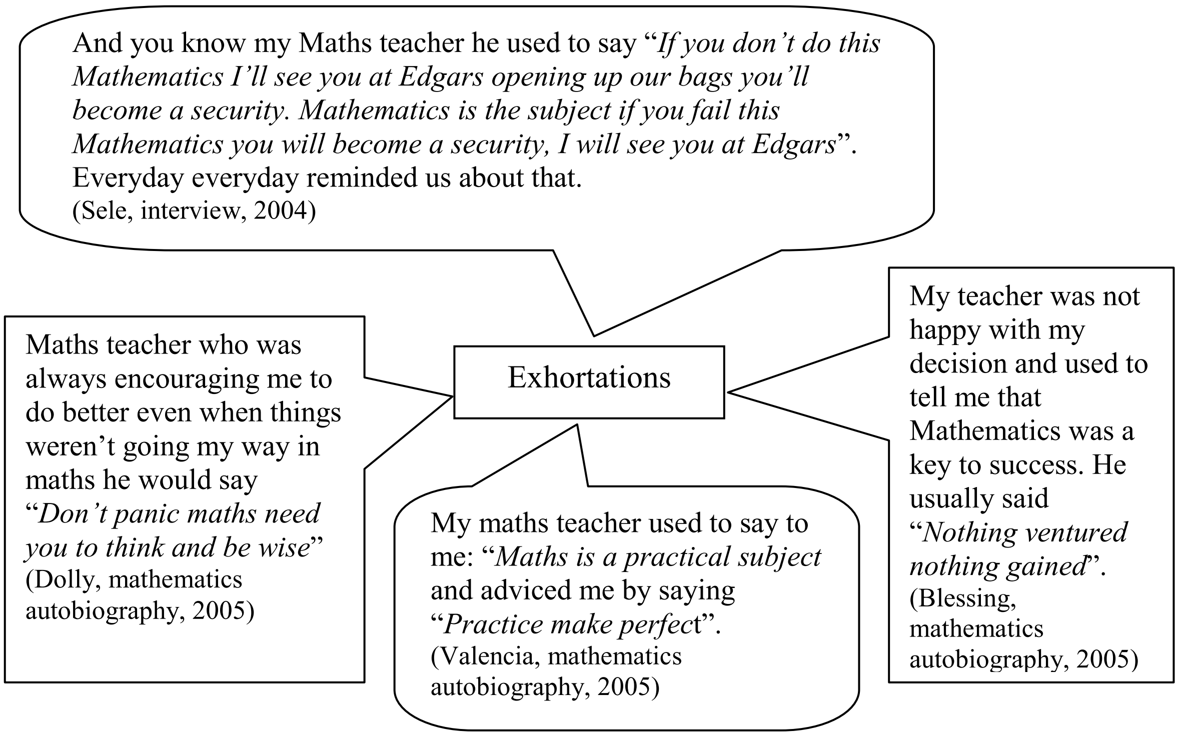


Figure 5.6. Things my teacher said to me - Exhortations

Self belief about ability and self efficacy

Attention will now be given to a discussion of the other factor arising initially from the questionnaire data - namely the Self factor. This factor, perceived on average by the preservice teachers to have a slight to moderate influence on their mathematical ability, encompasses self-beliefs about ability, confidence and efficacy in mathematics and self appraisals of their attitudes to the subject and the effort they put into succeeding. The evidence for the self factor found in the mathematical autobiographies and interviews is discussed in the ensuing sections.

The popular understanding that people are either born with a "mathematical brain" or not, is well represented in the autobiographical writing of the preservice teachers. For example, both Jane and Anisa included the phrase *I am not a maths person* in their mathematics autobiographies in 2003. Goodness identified herself as *mathematically blocked* and Masimezi maintained that *the main thing which discouraged me to love maths is that I know myself that I am not good on it* (2004). Perhaps the poor self-perception of ability is linked to the belief that *mathematics is for genious (sic) only* which was also expressed in terms of mathematics being a gift. Zami wrote : *I had every resources I need for my studies. I didn't come from a disadvantaged school. But I guess that since I wasn't gifted in the counting side I tried something else* and Kahjal too felt that *Maths is a complex subject made only for the gifted and it is unfortunately one that Santa never dropped down my chimne*y (2005). S'fiso seemed to be indicating that mathematics requires a special ability when he wrote: *I don't like to think a lot but maths was for a thinking person not a lazy one like me* (2003).

The previous discussion of dyscalculia (see section 3.3.2), includes poor judgement of measurement and poor ability to perceive spatial relationships as characteristics of this genetically determined syndrome. The following extract from Monica's autobiography suggests to me that she might well be suffering from this syndrome: *When I was young I realised I didn't understand things the way other people did. I could never judge just how far a metre was or estimate the distance between myself and a certain object. In fact I couldn't estimate much, it was as if I just didn't see it. It took me longer to grasp concept but I found once I understood how they worked it was quite easy to build on them. One of the main reasons why I dropped maths in high school was geometry. I could never differentiate between different types of angles. Even now when someone asks me to stand at a 45 degree angle I can never quite work it out, most of the time I just guess and hope it's right* (2004).

Interestingly, the mean scores for the items "my parents' maths ability" and "how clever I was born" in Instrument 1, the pre-module questionnaire, was low (see section 5.1.2) indicating that the preservice teachers on average did not see genetically inherited factors as having much influence on their mathematical ability. Other preservice teachers, although not indicating any inborn deficit, reported that their efforts were always in vain. Two examples of such sentiments include: *I don't know why math is so difficult for me because I tried so many times to understand it but I failed, I tried to learn math alone, as a group but I also failed I can't know why. ... I'm a hardworker* (Linda, 2004), and *I don't find maths to be scary, I don't find it to be a very bad subject, but its very frustrating when you do something over and over but just never seem to get it no matter how much or how hard you try. I wouldn't classify myself as stupid or anything, nor would I classify myself as lazy, I firmly believe that I am a hard worker* (Alarece, 2004). Madeline, too wrote of the frustration of trying and practising without success and the fear that *perhaps the teacher would ask me to do an example on the board…I would be so extremely humiliated, if perhaps, I would not be able to do the problem* (2005).

The failure experienced by the preservice teachers eroded their self efficacy beliefs and confidence, which in turn limited the effort they were prepared to put into mathematical work. Typically, the subject was put aside and given up as a failing cause. Thembani told himself *I am not good in Maths so why bother myself* and then simply *forgot all about it* (2004). Following a discussion in the interview, in which Sele had described a very poor learning environment in her school, I asked if any of the other learners had passed while she and her friends had failed. She replied: *They did pass that is why I am saying it was our lack of responsibility and discipline ... because ... I knew I could make it but there was no motivation behind us. You know we had to do it on your own and you say "Eish, this thing is stuck" then you leave it like that* (2005).

The following extract from an interview with Lindane provides a good summary of the way in which school experiences may shape the disposition of the preservice teachers towards mathematics: *I ended up having negativity towards Maths because I had told or succumbed or expected the fact that I couldn't do it. I was not clever enough to do it ...So I had this negative attitude from then on. When I changed to go to a multiracial school in 1995, this problem never improved because I found that if you had a negative attitude towards something from the first day, you are not going to have an improvement on that attitude. So it didn't help. I still had a negative attitude. I still couldn't do Mathematics although they tried. I think I didn't let myself try hard enough because of the bitterness that*

I had towards the people who ill-treated me because I didn't know how to do Maths. It went on and I hung on for a few years up until Grade 9 when I had never had to do Mathematics again (Interview, 2004).

5.4.3 The breakdown of mathematical learning.

The unifying characteristic of the experiences of many of the preservice teachers in this study is that their school mathematics experiences led to a feeling of disenchantment with mathematics, and that this happened at a clearly defined point in time, specifically mentioned in their autobiographies. It is important to consider the timing and nature of the critical incidents that triggered the disenchantment to gain insight into the mathematical experiences of the preservice teachers. I used the NVivo software programme to extract passages from the preservice teacher mathematics autobiographies and interviews which either described a critical incident, or identified a time when their attitude towards mathematics underwent positive to negative transition. The most common scenario described was that of a happy beginning in the early years of school, followed by an incident, situation, or series of incidents which resulted in disenchantment with mathematics. Many of these incidents have been described earlier in this chapter, notably under the teacher section were instances of unprofessional and abusive behaviour are cited.

Seventy autobiographies contained mention of a specific time when their attitude towards mathematics soured. Of these, 12 were in the primary years, 38 in the first two years of high school, and the remaining 20 later in high school years. The following quote typifies disenchantment: *When I get to high school most of the things changed. I develop a bad attitude towards it. So, I decide that I can do without it* (Blessing, 2005). The triggers for the onset of disenchantment can be put into three categories: (a) teacher factors, (b) schooling environmental factors, and (c) the mathematical subject content. Thirty two preservice teachers indicated that the teacher was responsible for their changed attitude. Reasons given include dislike of the teacher or failure to understand that teacher. For example, Logan wrote *from then because of an incompetent teacher everything changed. My eagerness and love for the subject died* and *it was then I started to hate maths because of our teacher who discourage us about maths and beating us all the time* (Nomcebo, 2005).

Thirteen preservice teachers mentioned the schooling situation where the change of teachers due to promotion or death, disrupted mathematics learning as did changes resulting from learners moving schools. Gloria explained it as follows: *The teacher was* *very good on teaching mathematics. Then early on my matric year he was shot dead and he was replaced very late on September. We did not cope and I realised that maths was never a subject for me. I told myself that I will never involve myself with mathematics* (2004). Lizelle wrote that she *then had to change schools and I just kind of lost it* (2004).

The actual mathematics subject content was a trigger for the onset of disenchantment for nineteen of the preservice teachers. Some of the comments were on the general difficulty of the subject, but most commonly mentioned was the symbolic use of letters in algebra. The idea of using letters (or alphabets as many students term them) in a numerical context signalled the end for them, as the following three quotes indicate. *At high school level things change. We begin to do algebra where we were solving for x. I was confused of solving for an x* (Vallencia, 2005); *Maths at high school became a major problem especially when algebra came into the question, as I could never pick up how x used to equal to y and just the way it worked in general* (Ben, 2005), and *I found this utterly confusing, believing that you cannot add, subtract, multiply or divide letters of the alphabet* (Suzette, 2004).

5.4.4 Stories of mathematical experiences up to the start of the MLE module

This research has been identified as a picture drawing case study (see section 4.5) and my intention was to allow many voices to tell the stories of the mathematics experiences. Having analysed the data, and following Bassey (1999), I now present three fictional letters that contain many of the assertions and generalisations about the case. These stories are fictional reconstructions of students' experiences, expressed as letters or emails to family or friends at home: The fictional students are representative of groups of students. Mfane is representative of students who came from rural areas into the university with little knowledge of university systems, and who had discontinued the study of mathematics at Grade 9 level; Pearl is representative of older students, also from poorly resourced schools but who had attempted Grade 12 mathematics; and Christine is representative of students from well resourced schools with good language skills, good computer skills and a good educational background in most other subjects.

The stories draw on the mathematical autobiographies of 254 students, over thirty in-depth interviews and information provided in the initial module questionnaire. Each point made is supported by the data, and referenced in the right hand column.

Mfane's letter home

To all my family in Nongoma	
I am sending this letter home with Vusi who is coming to visit this weekend.	
I think I have sorted out my registration now. The queues were long and when I got to the front I was told which subjects I must take as well as the Travel and Tourism and IsiZulu that I want to teach. We have to do subjects to help our English communication and the biggest shock is Maths. You know when I was filling this form, they said I must do Maths Literacy eish! I was very worried, I was like 'Oh this thing I've tried to go away with it it's still following me now.'	Siwe, interview, 2004
I have made friends with some other students who have also come to the campus from rural areas. We have been talking about home and the schools we used to go to, and really I didn't think the other students would understand how things were for us. I must say I thought that there is no white person who has a Mathematics problem. So when we were in Maths literacy class for the first time and I saw there were lots of white people, I thought that if they had the same problem then why not me. I came to realise that Maths is actually everyone's problem. Nobody in this class has passed maths in Grade 12.	Gabi, interview, 2003
You will remember how I battled with long division in Grade 6 and how upset I was to get 22% for that year mark. And how things got worse in Grade 7 and 8 when the teachers were only interested in the good students and we who knew nothing were simply the food of the cane so that we had to wear two or three trousers or a lot of T-shirts to make sure that whenever they starts their magic we were ready. After Grade 9 which was the most humiliating, devastating and shameful year because the teacher put me under pressure by always wanting to show off what a fool I was in front of the class, I was only too pleased to drop maths.	Msawenkosi, mathematics autobiography (m.a.), 2004
My friend Thembi has bad memories that go back even further than mine. She was only in Grade	Thembi, m.a., 2003

2 when she was punished so severely that her hands became too swollen to even wash herself, because she had lost her little stones for counting.

The first thing we have to do in the maths literacy class is to write about maths and me which is our own maths story. For most of us, the story stopped at Grade 9 when we did not continue with maths anymore. You all know how glad I was to stop but some of the students still feel very bad that they had no choice because of the system in their schools. Kwanda was not allowed to do maths because his brother had a place in the maths class, Olwethu applied too late and there was only room in the History class at the nearest school, and worst of all was poor Portia who was too shy and scared to say that she was in the wrong class and that in fact she wished to be in the maths group.

Kwanda, m.a., 2004

Olwethu, m.a., 2004

Portia, m.a., 2005

Although we are all a bit scared about doing the maths literacy, it is probably a good idea. Tshengisile has been telling us that when she was employed as a substitute educator last year she had a lot of trouble working out the year marks of the pupils and came up with marks of over 100%! We are doing it in order to be able to know numbers and understand them correctly, and because we don 't want to be like the teachers whom when you say to them you want help in Maths they would just say "oh, long time we left that thing, so please just contact Mr So and So".

Tshengisile, m.a., 2005

Siwe, m.a., 2004

Paul, m.a., 2004

The time to pass maths has come and we are going to do it by hooks or crooks!

From Mfane

Pearl's letter to a friend

To my friend at Wits medical school

Dear Bho

At last we can start to study for the jobs we dreamed of - at least you can. You were very lucky to have gone to a school in town and now I am writing to tell you about what I have been doing since you left the farm. I was living in the rural area and coming from a poor family. I can say is that in my family there's no-one who has completed matric, so it was obvious that I'll be the first child. But history doesn't mean your destiny. I was just learning and if someone asked me, "What do you like to be?" I was saying to be a nurse or doctor. I was growing with that in my mind. Because I was living in rural area I went to schools that were also rural and where no materials and there's no teachers. My grandmother used to tell me that I was going to be a doctor, but I used to tell her that was impossible because I knew me and maths don't get along. Maths doesn't even appear on my Grade 12 certificate because I failed it so dismally getting a H symbol. I suppose the main thing that discouraged me to love maths is that I know myself that I am not good at it. After I got pregnant my father says I deserve a punishment and wouldn't send me to study and I had to stay at home for three years. Anyway that is over now and I am excited to be starting my Bachelor of Education degree so that I can be a teacher.

Nomdumiso, m.a., 2005

Njabulo, m.a., 2004

Masimezi, m.a., 2004

Nomfundo, m.a., 2003

Actually the maths is not quite over. I have to do a module called Mathematical Literacy which is for students who have not got Grade 12 maths. Most of the people I sit with in the class also failed maths in matric and we were talking about how that happened. Stabiso says he was doing fine until grade 12 when they had five different teachers. He doesn't blame himself because he says almost everyone in the class failed and even those very intelligent pupils who passed got marks that were very disappointing to them. Gloria also had a bad year in matric - her teacher was shot dead in the first term and they didn't get another teacher until September so she failed.

Stabiso, m.a., 2004

Gloria, m.a., 2004

Bathabile had no teacher for Maths, Science or Biology in Grade 12 and so she had to go to another school on Saturdays for some tuition but that also didn't work and she too failed.	Bathabile, m.a., 2004
Menzi doesn't think he passed a single Maths test in Grades 11 or 12 and has avoided all maths and calculations since. I think we all agree with his view that it is very stressful to not know or understand a certain subject even if you are good at other subjects	Menzi, m.a., 2004
Even if the teacher didn't change a lot, there were problems for some of us as the teachers were useless and they pretended to know what they don't. Wilson had a horrible teacher that did not care whether they understood the work or not, she was too busy shouting at the class.	Benisanani, m.a., 2004 Wilson, m.a., 2004
Funny thing, I always thought that I would have been fine if only I could get to a good school in town, but that is maybe not true. Sebenzile went to a big Ex Model C school in Grade 10 and tried to do maths but was hopelessly lost as she had not done the previous years' work. She then had to change to another subject. Frances moved schools from a rural boarding school near Indedwe, to a school in KwaMashu and then to Model C schools in Durban North in Grade 6. She says that despite competent and kind teachers she always felt that she was behind and couldn't change her negative attitude to the subject.	Sebenzile, m.a., 2003 Frances, m.a., 2005
Anyway, we have just begun and it is a strange kind of maths and I am only hoping for the best. I just hope that something we are studying won't give me all the aches which exists in the world of diseases!	Malibongwe, m.a.,2003 Khehla, m.a., 2003
Your friend *Pearl*	

Christine's email

Hi everybody at home

As you can see I have organised my LAN access and so you can email me at this address. I have registered for all my courses and can you believe that I have to do a module called mathematical literacy! After all the upset with maths at school, I promised myself I would never have to look at maths again. It is all to do with the national drive to include a mathematical literacy component with each qualification. Lizelle has been working in London for three years and she says she got by just fine without maths so we don't really see the point of doing it now that school is over, but we have no choice. Lizelle, m.a., 2004

Anyway, I was sitting with some other students and we all complained together. Thinking back to our school days got us stressed all over again. Some of the students from disadvantaged backgrounds have awful stories of their teachers and totally under resourced schools, and so we feel a bit bad about our complaints. The students from town schools didn't have as many smart facilities as us but seem to have been more or less okay. We have to write a mathematics autobiography so we have been trying to think what shaped our attitudes to maths and why it is a problem for us.

Funny enough, we mostly seem to remember our primary school maths as being fun and manageable. Well, all of us except Karen who is still upset about the teacher who slapped her hands, ripped the wrong work out of her book and publicly asked her questions she couldn't answer. She really wants to be a teacher though, and so is going to try and cope with the mathematical literacy we have to do. Karen, m.a., 2004

Talking to the others, makes me realize that I must be grateful to you Mom and Dad for trying to help me through my maths frustrations - all the tears and upset, and all the tuition classes you paid for. Reshena, m.a., 2005 *It seems that other parents are not so accommodating - Shirley's parents refused to send her to extra maths and said if she couldn't do it, why bother.* Shirley, m.a., 2004 *The end result was the same though,* *neither of us continued with maths after Grade 9.*

Thinking back about why we didn't go on with maths, we found an advantage in being girls at a girls school! It was easy for us to choose another subject like Business Economics or Typing, and get on with Grade 10. At some of the boys' schools there is more pressure to do Maths to Grade 12 and Edward, Lloyd, Simon and Evan all battled their way through to Grade 12 and then failed.

Edward, m.a., 2003
Lloyd, m.a., 2003
Evan, m.a., 2003
Simon, m.a., 2004

In the end we decided that we just had had enough of maths and maths teachers, and were tired of the struggle. At high school it became a bit abstract and the xs and ys of algebra confused us (Suzette still does not believe you can add letters of the alphabet!), and we couldn't see how any of that was going to help us in the future. I was very lucky with my teachers who really tried to help me, but you wouldn't believe how mean some teachers were. Carol says she had a teacher who belittled them until they felt like idiots and because she hated that teacher's guts she hates maths now. Sheila can only tell us that all her maths classes at school were her worst and all the teachers were also the worst and she keeps saying "I can't do maths because I don't like it, I don't like it because I can't do it".

Suzette, m.a., 2004

Seema, m.a., 2003

Carol, m.a., 2005

Sheila, m.a., 2003

Estelle just gave up maths because her friends did and now she is sorry, so she at least is pleased to be doing mathematical literacy this year. The rest of us are going to give a good try - I will let you know it all goes.

Estelle, m.a., 2004

Cheers
Christine

5.5 SUMMARY

The primary research question addressed in this chapter was: To what extent do the preservice teachers entering the MLE module see mathematics as a useful and worthwhile subject, and see themselves as people able to learn and do mathematics successfully?

The preservice teachers indicated that mathematics was useful as a ticket to better jobs and study opportunities and some conceded it would be useful for daily life. There was little evidence of appreciation of the "sense" of mathematics as a coherent subject, on the contrary, it was seen as making little sense with letters of the alphabet mingling with numbers. The school experiences of many preservice teachers, vividly recalled, have eroded their confidence as effective learners of mathematics and led to a sense of disenchantment with the learning of mathematics. Likewise, the repeated mathematical failure experienced by the majority of preservice teachers in this study, seems to have resulted in a lack of confidence or a build up of resentment, both of which manifested in a resolve to avoid mathematics wherever possible.

Against this background of a very negative disposition towards mathematics, the antithesis of the productive disposition towards mathematics that is an essential strand of mathematical proficiency, the preservice teachers in this study were faced with the prospect of a semester of mathematical literacy. Most expressed a philosophical acceptance and a resolve to try to succeed, if only to put it behind them. The writing of both Monica and Menzi in the extracts below, indicated mature self awareness and a commendable resolve to succeed. *I hope that through this course I am able to understand these concepts and to develop the ability to use them in my everyday life. The prospect of doing maths again after eight years is quite daunting but I am excited to try it again because I want to understand these things for myself and I don't always want to ask someone else* (Monica, mathematics autobiography, 2004). *Since Grade 10 my maths hasn't been up to scratch. In Std 9/10 I never passed a Maths test. This worried me so much so that I ended up hating Mathematics. Since then I have not touched a maths text book nor practiced any piece of a calculation. I don't now I am going to cope with it now that I have to do Maths again. It is the subject I never wanted to come across with in life and I had given up hope of ever learning and understanding it. My maths problem began when I could not concentrate fully on it. I was stressed. .... In ending, I think this learning area will revive my love for maths and improve my understanding of the subject. I promise to work harder and work together* *with my tutor to solve this problem. It is very stressful not to know or understand a certain subject even if you are good at other subjects* (Menzi, mathematics autobiography, 2004).

These extracts conclude this chapter, a case study of the mathematical histories of three cohorts of preservice teachers doing the MLE module from 2003 to 2005. This has provided the reader with a detailed picture of the people engaged with learning mathematical literacy and a rich background against which to read the following chapter which is a three part story-telling case study of the implementation of the MLE module as it unfolded over three years.

CHAPTER 6

CHASING SOAP BUBBLES, SWIMMING WITH THE DOLPHINS, BUT LEARNING MORE THAN WHAT I DIDN'T KNOW......

I learnt more than what I didn't know (Xolile, module evaluation, 2004)

As previously described, this research project can be considered as two overlapping case studies embedded in the overarching case study of the MLE module. The first case study, that of the preservice teachers entering the module, was described in Chapter 5, and in this chapter the second case, that of the implementation of the MLE module over three years is described. This is a three part story, with each successive year described and presented as a separate section. The pedagogical practices employed in each cycle of the module are described in chronological order, together with the reflections and response of the teacher researcher, the preservice teachers, and the co-workers to the changing circumstances. This is interwoven with a discussion of the struggles and successes students experienced in the course of the MLE module. Data gleaned from Instruments 5, 6, 7 and 9 are discussed in turn, and included in the account of the module as appropriate. The report of the pedagogical practices employed over the three years of the MLE module will show that the initial pedagogical practices have improved in identifiable ways as a result of purposeful choices on the part of the researcher, made in response to a reflective self critique of practice, and listening to what the other participants in the MLE module had to say. New ways to support the learning of the students were devised, implemented and critiqued.

Clearly a large part of the determination of what constitutes a good pedagogical practice or learning behaviour will depend on its success in improving the overall mathematical proficiency of the preservice teachers, which is crudely measured by the academic results obtained. The final module mark will be used as the measure of success or failure in becoming mathematically proficient to the level required by the module outcomes, and to the level hoped for by the preservice teachers themselves. Changes in productive disposition will be discussed in the light of data gained in interviews and the final module evaluation. These are important features in determining the answer to both Research Question Two: How is the productive disposition strand of mathematical proficiency of preservice teachers changed after completion of the Mathematical Literacy module? and Research Question Three: What pedagogical practices and learning behaviours best enable preservice teachers to develop mathematical literacy? The chapter concludes with a commentary on the results and findings from all three cohorts, and how these findings relate to the literature reviewed in Chapter 3.

6.1 THE STORY OF THE MLE MODULE - PART ONE

2003 - A BRAND NEW MODULE

At UKZN this was a year of transition and new demands on workloads. Consequently, I was asked to tutor on a foundational module, Academic Learning in English, compulsory for all first year students. This involved working with about 20 students twice a week developing academic reading and writing skills. It so happened that some of these students were also in the MLE class, so in the same year, it was possible to get a good sense of both the numeracy and literacy competence of the first year students, and develop some insight into how they were experiencing university life.

6.1.1 The 2003 module unfolds

Following a pilot study conducted in 2002 with all first year preservice teachers in the Bachelor of Education degree, it was expected that the number of students that would enrol in the MLE module in 2003 would be small since less than 15 preservice teachers specialising in the secondary phase had been identified in 2002 as not having passed Grade 12 mathematics. With this in mind, the plan was to develop a curriculum in response to the needs of these few students, and for this to be taught by myself alone. In the event, national imperatives for teacher recruitment and changing institutional goals resulted in a large first year intake of students, many of whom came with poor matriculation results. Table 2.5 provides the detail of the demographics of this cohort in comparisons with the two cohorts that followed. In summary, there were 71 preservice teachers enrolled for the MLE module, of whom 61% were female. The mean age was 22,5 years with half the preservice teachers over 20 and a quarter over 25. The cohort was predominantly African (67%) with equal numbers of Coloured, Indian and White students making up the balance. The preservice teachers came with generally poor school results as evidenced by the finding that only 18% were recorded as having certificates of complete matriculation exemption and 84% had below the 32 points required in 2006 for admission into the Bachelor of Education degree. Typically, a student in the MLE module in 2003 was an African female, older than the average first year student and with a school record that would not normally allow entry into university.

Due to the larger than expected numbers, another lecturer was assigned to this module and the teaching was shared. It soon became apparent that some of the preservice teachers were battling and so some of the Post Graduate Certificate in Education (PGCE) students were employed as tutors. The tutorials were arranged at various times during the week and attendance was voluntary. The first test saw the preservice teachers stressed and pressed for time, quite out of line with the intended spirit of the module. *We watched the students battle their way through a test, with fingers frantically going and covering paper with screeds of long handed computations. They obviously need quicker methods, and more particularly the insight into when computations are necessary. And now so many didn't finish and I was back to rushing people out of the door when they still had work to do on the paper* (Teaching Journal, 19 March 2003).

Statistics formed a large part of the MLE module due to its obvious usefulness for teaching. In contrast to the earlier sections of the module in this initial year, which had been developed somewhat as we went along, this section was fully prepared and put together in two booklets, one for notes and the other a workbook. One of the initial tasks was to work in groups to sort out categorical data collected from the group on favourite fruits, motor cars and so on. After noting that once again we were rushing, I noted that the preservice teachers had *rough work all over the nice pieces of paper for their task to be displayed, Part 2 data all over the grids for Part 1 and confusion was King* (Teaching Journal, 26 March 2003). The preservice teachers seemed to become unsettled and irritated by changes in the module routine and I noted in my journal that Richard remarked *Ma'am I am getting confused. And when I get confused I get stressed and then I just can't do anything. That's what happened to me before. I can do the graphs but this group work just confuses me* (Teaching Journal, 26 March 2003). When the data handling test was written a few weeks later, and the mean was 33% it was clear that many preservice teachers were in trouble with the work.

Reflections on the data handling test

In an effort to gain some insight into the source of the difficulty, Instrument 6 (2003 version) as described in Chapter Four, was used. This was an informal questionnaire filled in during the course of the lecture in which the tests were returned. The data derived from it was largely qualitative and indicative of the prevalent learning behaviours, discussed below.

When asked about the time spent on preparation for the test, the responses varied from frank admissions that very little work had been done, to accounts of real efforts to engage with the work: Nine preservice teachers indicated that they were inadequately prepared for the test due to pressure from other subjects for which they also had tests or assignments due. For example, Gamlakhe indicated that *due to time constraints I spent less time to prepare than I would have loved to. I had many assignments that I had to research and complete, although maths is my weak subject I tried to put more effort in my work two days before the test*. Both Sindi and Kwanda indicated that their preparation was limited to the organised tutorial time saying *I did not spend any time of my own except tutorials* and *I spent more time on the tutorials where I have been helped but not much time by myself.* Some students, however, organised themselves into groups and made an effort to get help. This is exemplified by Philisiwe's account: *I prepared myself for the test by getting through all the work that I have learned in class and went to some of the student to study with them. Altogether we went to the other student who are doing maths as a major to help us but no help was found because they did not know it so we had to study by ourselves*. It is interesting to note that apart from Sindi who passed well with 62%, the marks of the other three preservice teachers cited above were failing marks (Gamlakhe 26%, Kwanda 44% and Philisiwe 16%).

The prompt used to elicit what the preservice teachers perceived as their strengths and weaknesses, drew comment on their performance in writing the test. These referred to the "tricky" nature of the test, the shortage of time in which to answer or the related issue of working too slowly, and a general despair at their inability to comprehend the work. Firstly, one of the competences associated with data handling is the ability to correctly choose a graph suited to particular data, and in the test a data set was given and the preservice teachers had to select suitable data to draw various graphs. This was novel to them, but a small step from the clearly expressed criterion of determining suitability of graphs to data found in the notes. Nevertheless, Musa complained: *I didn't expect the way the test was set. If it was set according to the way we're taught I suppose I would have done well. The problem I am facing now is that when I am revising for the test I see everything easy but when the test come I got shock in every maths test I am trying to do*. Other preservice teachers remarked that although they were *fully prepared, the problem was the short time in the test. I was I was confused because I didn't finish* (Mamello), and *time was not enough*! (Jackie). Pressures from other modules also played a role within the test time as Sebenzile testified; *my weaknesses was I am very slow and misunderstood some of the questions and that led to my downfall. My strengths I don't think I had any because there were too many things on my mind e.g. P.L.O test*. In other cases, the preservice teachers identified their poor background in mathematics as the root of their difficulty. Three cases stand out, as none of the preservice teachers quoted below achieved more than 5 marks out of 50 for the test. Amos claimed *my difficulties are that I don't understand the methods of maths. I also do not know how to collect that data and where to find them. About the methods I did not know where to start with my work* and in the same vein, Khehla remarked: *The only key areas I have are those of difficulty, because I don't understand maths at all, even those simple things on maths. It's been a long time since I did maths in grade* 9. The time elapsed since school study of mathematics was also alluded to by Victor who stated that his *areas of difficult (sic) is poor background in maths I leave mathematics at grade 8. I find it difficult.*

Forty three preservice teachers expressed disappointment with their mark. Others adopted fatalistic views such as *I am not disappointed, that is what I have been waiting for by looking at my record of mathematics* (Victor) and *I am very disappointed but I knew it was going to be like this* (Musa). There was a lot of disappointment at the perceived lack of reward for hard work. For instance, Thembi admitted her disappointment with her mark of 20% *because I try about a week to study maths but my study is worth nothing* and Philisiwe was disappointed with her 16% since she *studied very hard to get a high mark but that did not happen* and Phindile wrote *I'm totally disappointed because I always try my best but, still get the 'unexpected mark'. I don't know why I fail these tests because I do learn.* Phindile's unexpected mark was 12%. At the other end of the achievement scale, Shannon who scored the top mark wrote: *I am really happy with my mark I honestly thought that I would fail. I worked hard so am pleased with my mark.*

Finally, the preservice teachers were asked what plans they had for improvement, and how I could help. There were many resolutions to work harder and practice the graphs, and to attend tutorials. However, some preservice teachers had no ideas. Promise indicated that she had *no plans because I do not know what to plan. I think sometimes I understand what was going on in the class yet I was not* and Khehla said simply *I don't know, definitely no idea*. The suggestions for lecturer assistance were mostly related to specific content that could be retaught and the style of the test. *Aside from making the questions easier, we should be given more time to write our tests because thinking under pressure* *does not help the situation* (Seema). The suggestion made by Leroy that the questions not be made *so complicated so that we can understand what we are reading* is likely to indicate a difficulty with the statistical language rather than the language of instruction since Leroy is a first language English speaker.

The situation was muddy and no clear work/ result relationship was evident. S'fiso indicated that he was well prepared having spent 40 minutes per day, but that in the test experienced a *misunderstanding of the data leaves (sic) and no key areas of strength* and further that he was disappointed *because I did not take enough time to read the question*s. He scored only 3% on the test - the lowest mark. In contrast, Shannon, who also felt she was well prepared having *learnt really hard for the test, I used examples in our notes and did them. I understood a lot more once I practised sums,* achieved the top mark of 73%.

A critical point in the module came when the final class mark was calculated and those who had achieved below the required 40% were not awarded a Duly Performed Certificate (DP) which allowed entry into the final examination. Thirteen students did not earn a DP for the module. After the examination results were out, and the supplementary examinations written, the hard truth was that 55% had failed to pass this module. Sizwe's lament that this Mathematics Literacy requirement in the Bachelor of Education degree has *wiped off my hope of getting a BEd* (module evaluation) rang true for nearly half the students.

6.1.2 Preservice teacher reflections on the 2003 module

In the first instance, the reflections of the preservice teachers were recorded in a module evaluation questionnaire (see Appendix I), and in the second instance they were given an opportunity to speak about their experiences in the MLE module in personal interviews. In order to facilitate comparisons between the three cohorts in this study, the interview data was combined with the general comments made on the module evaluation, and is discussed using the headings suggested by the subscales identified by the factor analysis of the more extensive questionnaires used in 2004 and 2005 (see section 6.2.2). This is a post hoc organising framework and so the data are not evenly distributed among the scales since some of the themes did not arise in the informally structured interviews.

The final module evaluation did not have many focussed questions related to the teaching of the module, but rather had more open questions such as whether having done the module, they would have chosen to do the MLE module if they had the choice, and a general invitation for comments. More than half (57%) of the preservice teachers who answered this question on the module evaluation, indicated that with the knowledge of having experienced the course, they would not have chosen to do it. Their reasons were typically related to the difficulty of the work, a dislike of the subject mathematics and the threat the module posed to their overall aim of achieving a Bachelor of Education degree. For example, Stembiso wrote: *If I have had the choice I would not do this course because I found it very difficult and discouraging and it diminished my hopes of acquiring a B.Ed degree.* Gamlakhe, Khange and Jackie were all blunt in their responses to whether they would choose the module: *No, simple reason. I hate maths; No, I don't like maths and I won't like it ever!* and *No, I am not a mathematical person. Numbers frighten, frustrate and irritate me*. In contrast, 43% of the preservice teachers indicated that they would choose the module, mainly because they enjoyed the classes and found the module content helpful: *Yes. It is relevant to life and teaching (especially data handling). It is a course that can be enjoyable and relatively easy to pass if you do the work* (Richard), and *Yes, we could easily identify with all the sections we covered, better than doing Mathematics in school* (Ruth).

Personal and mathematical development: this scale is concerned with whether the preservice teachers felt that they had developed personally and mathematically. There was a good deal in the content of the module in 2003 that was new to the students - very few would have heard of the patterns of logical reasoning, and much of the statistics before, so it follows that those who passed had developed mathematically by learning new content. The personal development, though had to be self-reported, and several preservice teachers spoke and wrote about their increased confidence and improved attitude towards mathematics. Rory, a student who achieved very well in the module, explained how his confidence had grown and he had begun to enjoy mathematics. *Just the mention of the M word made me mad. I really tried to do everything else but Maths and the course really changed my mindset about Mathematics. I've become more confident. That's the truth. .... I could have done better, but I am glad I have passed it and my mindset with Mathematics has changed phenomenally, so thank you*. Jackie was a married woman of 28, heavily pregnant with her fourth child. She provided a vivid description of her apprehensive start to the module, what she learnt, her struggles and eventual failure. *Yes I was stressed before I started because I hadn't taken maths and every body I knew encouraged me and said "no try, try we'll help you." …When I first started doing maths literacy I was shocked because I had no idea as to what was going on….Although I found it hard I learnt much you know from it, like even now my whole budgeting has changed and this maths course actually did help me even though half of my brain doesn't want to admit it, the other half admits it. It* *helped me especially when we used the rounding off of numbers, you know when you are in the shopping centre and when you are just like assuming how much it is and all that. And then also how to read on the pie graphs. When you are reading the news paper and when you are watching TV and they have got these graphs at least I have got a better understanding of … where to start and you not just looking at all these lines and all these circles. So it did help me….Now when I did fail I was so devastated I went home and I actually cried and I said to my husband, I tried so hard, I did try, and he said ag its ok it doesn't matter you do it again next year. But I feel confident so I am going to do it over hey?* It took another three years of gradual mathematical development before this story had a happy ending. Jackie had to deregister in 2004 due to family commitments, returned in 2005 and failed again, and finally passed after doing the special repeat class in 2006. Susan too, was a more mature student in her mid thirties, and she spoke enthusiastically in the interview about her personal and mathematical development through her engagement with the module. *I allowed myself to believe that Maths is not for me…. I think a lot has to do with how you think. I allowed myself to believe that Maths is difficult and at this point, after having come to Maths literacy, I don't think Maths is difficult. I really don't think it is…. I now have that freedom and passion to say let me try it. I wasn't like that before. I am now more enthusiastic than I was before….I must say that I never had a chance to speak to you privately. I want to take this opportunity to say that you really made a difference in my life as far as Maths is concerned and the way in which I think of myself. You made me think. You changed my perspective towards Maths and I've never had one of my Maths teachers do that for me when I was in school and the course has really made a difference in my life….So I must say thank you very much.*

Lecturer expertise, clarity, and enthusiasm: This scale concerned the sentiment that the lectures were well prepared, delivered clearly and enthusiastically and in accordance with principles of non-racism and non-sexism. While on the one hand there was little to support this in the interviews where I focussed more on asking about the difficulties students experienced, on the other hand there was no contrary evidence either. The only relevant comment found was from Jackie who remarked *that both maths teachers were excellent, relaxed, understandable and patience with me and the rest of our class.*

Level of difficulty of work: This scale dealt with the preservice teachers' perceptions of their ability to cope with the language, pace and level of difficulty in the lectures. The response to questions in the interview regarding the language of the lectures was mixed.

Sizwe felt that *the language was not a problem. I think the only problem was with the graphs itself*. When asked if he could understand the English used in the lectures, Victor replied *Yes. Not as from the word go. I started to understand at the end of the semester*. Amos, Siphamandla and Promise all clearly indicated that, for them, English had been a barrier to their learning. *Language a problem? Might be but I understand about the language yet I'm not quite right in English as it is not my home language* (Amos). Siphamandla indicated that he felt a need to improve his spoken English which I had remarked was good, and also to master the mathematical English. *English is not our language. I'm not trying to defend myself….I don't speak perfect English because there is nobody who is going to tell me every time that I am making a mistake, so I keep on repeating the wrong things. English is very difficult but I am trying my best to understand it… because I couldn't understand some of the terms and some of the handouts written in English. Some of the sections I couldn't even understand what was going on in those sections. I used to try and write it in my language and understand it here and there and see what is being asked or what the section is talking about.* Promise spoke of another aspect of language difficulty, that of the mathematical and statistical meanings of words, that is the Mathematical English and Statistical English that is interspersed in mathematics classrooms with the Ordinary English in everyday use. *It* (the language of the MLE module) *was a big problem for me. Sometimes I could take a dictionary and look for a word, for the meaning of the word. Sometimes I couldn't even understand even when I looked up the meaning and I have to ask someone to explain it to me.* She went on to cite as examples *possibilities, probabilities and all those words. They were so difficult for me to understand.* Siphamandla found the module content very difficult. *It was very difficult…I really found it very difficult… There were things which I have never heard before or had never been taught… Also the other things are the data handling. I couldn't understand how to answer those questions….Even if I wanted to do homework, there were exercises, which I could see that I could not do. I could spend hours and hours trying to do one of these exercises and could not do this.* He agreed that the pace of the lectures was probably suitable for most people and quite understood that there was a curriculum to complete, but nevertheless felt that he needed more time. *I am that kind of a person, I don't understand things very easily like other people, and I take time to understand things. I need that attention until I understand that thing. So, I cannot say that you were very fast because there are other people who could understand it easier than me*. It was clear from the range of marks achieved throughout the module that there was a wide range of ability in the class. Lloyd thought that the difference might lie in the fact that some students had studied mathematics to Grade 12 level. To him, *it was evident that we were all at totally different levels sitting in there. You had some that were good and some that really just didn't know what was going on at all*.

Culturally responsive class ethos: this scale is related to the preservice teachers' agreement that the class ethos took account of cultural and language differences. The lectures were all in English, and in 2003 none of the tutors were first language Zulu speakers. This proved problematic for Sipho who was used to the code switching common in schools where staff and pupils are all isiZulu speakers. *As a person from a rural area, Maths was not difficult to me because it was taught in first language and then sometimes explained into Zulu language. So such things become much easier, unlike the one that we did in our last semester where everything was taught in English and not explained in Zulu …So it gave me some difficulties and I tried to do all the work, attending all the lectures, but it did not help*. There was no mention of racial tensions, but that is not to say that the racial differences were not noted by the students, some of whom were surprised to see white students in the class and expressed a wish to interact more with other race groups. This is well illustrated by the following extract from an interview with Gabi who was talking about the formation of working groups: *Especially me, I though that there is no white person who has a Mathematics problem. So when we were in Maths literacy I saw there were lots of white people and I thought that if they had the same problem then why not me, and so we came to realise that Maths is actually everyone's problem. I think you should split the people randomly. Get to know each other. Not black together, because in some way it discourages you because maybe your friend who is close to you don't know a thing, so when you are close to the other people you get to share and understand more.*

Module assessment: this scale was concerned with the preservice teachers' perceptions of the helpfulness and fairness of the assessment in the module. The two comments on this aspect expressed completely different sentiments. Susan appreciated the fact that the classwork was included in the module mark: *What I like about the Maths literacy course … is that it was balanced. We had 50% continuous assessment and 50% on tests and exams. For students like myself, I was able to come around when we had tasks to complete, like data handling, and that really helped me to pass Maths.* Sipho, however, was very aggrieved that his failing mark of 46% was not converted to a pass and he wrote me a letter to this effect, and brought it up in the interview as well. *I attended all the lectures, doing* *all the tasks given to me, putting much effort into my work, but it did not help. You are very strict in the above-mentioned matters but we don't have any benefits, like if you kept all these things and you got 46% in the exam, you should add 4% because this thing is new to us.* In the interview, I explained that the mark was a combination of a lot of marks and it was not really policy to add on marks due to a sympathy motive, and furthermore my primary aim was for him to know and understand the work. He was not convinced adding *I know that Mam, but you should think that this Maths literacy is new to us and is not easy to understand some concepts as they are also new to us*.

Lecturer encouragement and personal effort scale: these scales, discussed together, concern firstly, the perceptions of the preservice teachers of the motivation and encouragement provided by the lecturers, and secondly, their perceptions of the sufficiency of their own efforts. Seema, Lloyd and Rory all expressed thanks for the contribution made to their mathematical and personal development writing for example *Thanks... for not judging us if we failed or did poorly in a test also for making maths literacy "FUN"* (Seema), and *thanks ...you have made me a confident person, and nobody can take that away from me* (Lloyd). More able students such as Lloyd conceded that they could have made more effort and achieved really high marks. He said at the end, when it came to the exam, *I took for granted because my DP was so high, I didn't even bother to study really for the exam. I don't know why, but I thought that I'd got a good enough DP; I just ran over the work and thought it was OK*. In the end he was a little disappointed with his mark. Susan described very clearly the adult responsibilities she had in addition to her full time university student role: *In the first three or four months I was really battling because I have my home life and my four kids and when I get home, my twins are in Grade 3 at the moment… So, I've got responsibilities, but it's not a big train smash because I know that this is what I want to do. I have to make a sacrifice. So when I get home, as much as I've got a lot to do, see to the kids, monitor their homework… Now with all of those responsibilities I was finding it difficult to adjust to my studying because this is now full time. The other one* (her previous studies) *was just lectures twice a week in the evenings so I had time to cook and clean and do everything else*. In contrast to this mature attitude to work, were the reports of preservice teachers who had made less effort. The more successful students dismissed those who didn't succeed with comments such as *they are lazy* or *they are not serious, they sleep on their beds while we came to the tutorials* (Boni and Promise) and *they are so lazy. They didn't ask questions. I mean, we used to discuss mathematics as a group so that we would be able to write it. They were not interested in* *doing that. They were not asking for help, they would just sit* (Nozipho). Susan considered that *some of them were just lazy. I considered myself as really weak in Maths and I said to myself that I am now at university and no longer at school … I need to take the initiative and I used to work a lot on my own.*

Helpfulness of tutorials: This scale concerns the perceptions of the preservice teachers of the role of the tutorials in aiding their learning. Most of the comment was positive and the preservice teachers felt that tutors had in a sense rescued them. *At first I thought I was going to fail it, but when they introduced the tutors and stuff it helped me, and the small groups where we come to share our experiences and things and we come to know each other well and you realise that it is not only you that have the same problem and other people have the same problems too so you become relaxed* (Gabi). Siphamandla said that he *really liked those guys that were helping us because sometimes they will keep on repeating that section until you understand and we used to have more time*. Amos felt that he needed more individual attention and the tutorial groups were still too big. *Ja tutorial is not quite right because every body has a problem in class, no one has a time for you, you have got a short time at the class room at the class and in the tutorial and everybody is having a problem and needs help from the tutor*. In seeking clarity, I asked if what he was talking about was somebody to help him on his own and he replied *Ja on my own*. As alluded to in the section on personal effort above, some students ascribed the failure of their peers to their laziness to attend tutorials, which does indicate that the tutorials were perceived, at least by some students, to be useful.

6.1.3 Co-worker insights

The five PGCE students, Lorraine, Umesh, Therese, Alice and Liska, who had been involved in tutoring the preservice teachers in the MLE module were interviewed on 28 October 2003, once the interviews with the preservice teachers were completed. The interview was in the style of a focus group interview (see Appendix P). The first point of discussion raised was that of the knowledge and skills the tutors perceived the MLE students to possess when they first met them. *Some of them didn't have any skills at all - it was very scary. It was as if they had never learnt the section before. They had no idea* (Liska). Lorraine felt that the situation was not hopeless as once they had tried one example the performance was much improved. However the lack of basic skills had been evident. Umesh elaborated on this point: *I had to start everything from scratch to explain* *what percentages were…how you convert a fraction to a percentage. It was very easy but they didn't know how to do it. They didn't know what half was.*

Despite the difficulties with the content of the module, all the tutors agreed that the preservice teachers who attended the tutorials were largely positive towards their studies and eager to learn. *They were eager but frustrated by wanting to learn. They wanted to learn and everyone wanted your attention. They became uneasy when they didn't understand* (Therese). When asked to identify some barriers to learning that made it difficult for the preservice teachers to understand, Umesh immediately suggested language and there was a chorus of agreement. He added by way of an example, that *what I have done on the board, they tell the exact same thing to each other in Zulu*. On the same note, Alice felt that the problem lay in not understanding what the question means and what was required of them. Lorraine was of the opinion that the barrier was more a lack of basic skills and having no clue where to start. Having discussed the problems, the tutors were then asked to suggest improvements and innovations for the teaching and learning of the module in 2004.

The first suggestion was to help with the language problem but no practical solution was offered. The tutors had noticed the relatively mature age of some of the preservice teachers and suggested that they had forgotten their basic mathematical skills. Liska suggested a full day crash course to get their memories back into maths thinking. Lorraine remarked that this might not be helpful as they may not have any maths thinking to remember, and made the more practical suggestion of a basic skills text to fill in the gaps, and perhaps an initial diagnostic test of basic arithmetic skills. With the input of all the comments from the preservice teachers themselves, and my co-workers, it remained for me to consider the best way to proceed with the planning of the 2004 cycle of the module.

6.1.4 A way forward for 2004

From my personal perspective, the most striking and obvious general problem was the low pass rate in the module, indicating individual struggles on a personal level for each preservice teacher. The causes of the problem were not so clear cut, and after the first cohort of students in the MLE module my ideas were merely speculative. First ideas included poor time management both in organising learning across all modules, and within the test situations, general personal and academic disorganisation, language difficulties, a crippling lack of basic arithmetic skills and an absence of a productive disposition towards mathematics learning.

Reflecting on all of the above, it was clear that almost half of the preservice teachers in the MLE module had not been enabled, or had not been willing to learn sufficiently to pass. Whilst thinking about how to do better in 2004, an unexpected opportunity arose in that the fourth year mathematics major students in the Bachelor of Education programme were short of an 8-credit module in their degree programme and this was given to the subject specialisations. I offered to use this module to introduce the four mathematics major students to the challenges of teaching mathematical literacy, both at school level in the new curriculum, and to older learners such as the preservice teachers in the MLE module. The practical component of this module entailed working as tutors in the MLE module, and reflecting on this task. At this stage, I envisaged small groups of less than ten students per tutor and thought that this would be a very promising method to support the preservice teachers in their efforts to master the MLE module content, and looked forward to working with the 2004 cohort in the company of four tutors, Kirsty, Matthew, Debbie and John.

6.2 THE STORY OF THE MLE MODULE - PART TWO 2004 - INTRODUCING A FORMAL TUTOR SYSTEM

The beginning of the 2004 academic year was a time of transition in the Faculty of Education as students from the merged institutions came together on the Edgewood campus. The biggest surprise for me was the number of students required to do the MLE module - eventually 143 students. This necessitated negotiation for a bigger venue and the lectures took place in a large lecture theatre where a microphone is required to be heard. This impersonal teaching environment was somewhat redeemed by forming four smaller tutorial groups, one for each of the tutors. I introduced a colour system for the groups to simplify the administration - for example, the green group was Debbie's group, and all registers, marklists and notices relevant to that group were printed on green paper. This had the effect of creating four classes which met for plenary lectures rather than a daunting crowd of students.

This cohort of 143 preservice teachers included 14 repeat students from 2003, and 10 students who were also in a way repeats as they had failed Basic Mathematics (an alternative foundational mathematics module, see section 2.3.3) and were now doing the MLE module instead. There was an increased percentage of female students (64%) and an increased proportion of African students (79%). Slightly more students (24%) entered with a complete matriculation exemption than in 2003, but the matriculation points recorded for each student were low, with 55% having less than 24 points which is generally regarded as the minimum for entry into the university. Only 8% had over the 32 points which by 2006 were required to enter the Faculty of Education. The mean age of the students remained constant across the three cohorts at around 23 years.

6.2.1 The 2004 module unfolds

The unfolding of the module in 2004 is captured in the reflective writing of the tutors, as well as my own teaching journal.

Introductory weeks

The tutors were introduced to their groups and were well received and pleased to discover that they were really appreciated. *I will never forget the first session when I told them that I was there to help them and that they could ask me any questions, they all started clapping and some of them even hugged me. I was so surprised, since I thought the students would have expected this, but they didn't* (Debbie, Tutors summative reflection, 2004). By the end of the second week of lectures, the student enrolment had settled. I wrote that the groups were pretty organized and despite several newcomers in the past day, I felt that *most students were able to say which colour group they were in and in particular who their tutor was* (Teaching Journal, 27 February 2004). This doesn't sound like much to write down, but the experience of the previous year had shown how generally disorganized and easily confused some of these students could be. I attended some of the tutorials to get a sense of how the preservice teachers were doing since it was difficult to gauge this in a large lecture group. In one group, in the midst of a discussion about what nine tenths plus another tenth was, a male student said that really he couldn't do the numbers at all, not even the counting. Later Matthew mentioned others who had a similar problem and when Kirsty came looking for me to say that her group all want extra help during the week, it was clear that some remedial action was required. Consequently, instead of soldiering on with the commutative property of operations as planned, a consolidation "numeracy boost" week was implemented in the run up to the first test.

Questionnaire: How are you getting on? (Week 4)

Also in this week, Instrument Five (see Appendix E) was administered to get a sense of how the preservice teachers thought they were getting on. The results are provided in Table 6.1, together with an indication of whether the preservice teachers selecting themselves into a category eventually passed or failed the MLE module, and the mean mark for each category.

Only six preservice teachers (all first language English speakers) indicated that they were managing well and didn't need the tutorials, and in the end they all passed. The mean mark for this group, 71%, was statistically significantly higher than the means for the other groups (see Appendix V). Just over half of preservice teachers indicated that they were battling a bit but managing, and yet 17% of them eventually failed the module. Those who indicated that they were not coping at all, had a lower pass rate than the groups that were more positive about their performance. The use of an independent samples *t*-test revealed that the difference between the mean data handling test score of the group that was battling a bit, and the group that was not coping at all, was not statistically significant at the 5% level.

Table 6.1 Responses to "How are you getting on?" 2004, and subsequent achievement in module

Statement	N	Final module Mean %	% Pass	% Fail
I am managing well and am confident in my ability to do this work depending only on the lectures.	6	71	100	0
I am battling a bit sometimes but think I will manage with the tutorial lessons as well as the lectures.	75	57	78	17
Help, I am really not coping at all. I need extra lecture time to help me catch up on my basic skills.	44	54	73	27
Absent from lecture so data missing	17	51	41	59

Perhaps the most telling data is that which was missing because the preservice teachers were not present at the lecture in which the questionnaire was completed. This group did poorly in the module as a whole. Some of the preservice teachers added comments as invited. All the comments in the ensuing section are taken from this questionnaire, which is not referenced each time. These ranged from expressions of confidence to admissions of complete confusion. On the positive side, Leon said *the main lectures, as well as the exercise packs, are more than enough to give me the knowledge I* *need to practice at home*, and Shakira also indicated that she was *managing at this moment in time*.

The repeat students were naturally apprehensive. For instance, Thokozile wrote: *I am really battling with Maths, I failed it last year and I don't know what will happen this year, but it's highly likely for me to fail again. I really need extra help*. In addition to those repeating the MLE module, some of the preservice teachers had failed Basic Mathematics (for Foundation Phase teachers) the year before and had changed teaching specialisation phase which meant that they now had to complete the MLE module. They too were anxious due to their bad experience the previous year. *I think I need help because I failed basic maths last year. So I am afraid that it will happened (sic) again. I can see that I am battling with decimal fractions. Very scared for the coming test* (Thembani). A similar sentiment was expressed by Thuthukani who explained: *because I am from basic maths now it looks like I am swimming with the dolphins because I am left behind and I never done maths at school. I did it to grade seven which was Std 5.*

Interestingly, two preservice teachers queried the content of the module and suggested content more in line with school type mathematics. Bathabile, for example, felt very confused and suggested that I *have to try to teach at least some matric syllabus as I was doing maths in my matric - this thing of decimal and scale are really confusing me*. This suggestion was endorsed by a request to *please try and link the maths you are teaching with the one we did in matric, this is a bit too much of O.B.E. Try ask us how we did some sums at our matric level. This method your (sic) using is a little bit confusing and if we link with our school one it will be better* (Mmathapelo). Other comments about the content of the module to date (basic measurement, decimals and scales) were that it was different to that which was recalled from school, and in English. *I never did maths of this kind and the worst thing it was in Zulu in the primary school. I need good clarification when it comes methods of doing this maths. Please I think I need to be help from scratch otherwise I am lost!* (Goodness).

Even at this early stage in the module, the large size of the class was beginning to emerge as an issue. Praise indicated that he judged himself to be in the "battling a bit" category *because I can not understand in a big class* and this opinion was supported by Sinoxolo who wrote: *I really never got to know nor understand what was going in my lecture. It's as if I'm there for the sake of not being absent. And if I do get to understand than by the time I'm out the door I've forgotten everything.*

As the semester drew to an end and the class marks were calculated, it was evident that some students had not done well enough to be admitted to the examination. A personal recollection of mine is of the difficult time when those who had failed to earn a Duly Performed Certificate (D.P) had to be told. It was upsetting to see the resignation of some students who were seemingly well used to failure in mathematics, and the frustration of Bathabile who flounced out of my office adding at the doorway *I hate maths literacy!* Later she wrote in the module evaluation *it is very difficult, I don't want to do it again never, its very frustrating*. The following year, on repeating the module she passed with 51%.

6.2.2 Preservice teacher reflections on the 2004 module

Reflections on the module were expressed by the preservice teachers, the tutors and myself. The module evaluation (the 2004 version comprised items 1-36 of Appendix J plus one more question on tutorial support), was the general vehicle for the preservice teachers to express their opinions, with the interviews providing more detailed and personal data. The results of the analysis of the Likert type items on the module evaluation are discussed first. The 2004 module evaluation consisted of 37 items and so exploratory factor analysis, as described in section 4.6.7, was used to see if the number of variables in each of the subsections could be reduced to make the interpretation clearer. The first section, items 1 to 8, related to overall perceptions of the module. Following the procedure outlined by Field (2005), the correlation matrix was produced and the determinant of 0.174 met the criterion of being more than 0.00001. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy statistic, computed at 0.76, was higher than the recommended minimum of 0.5, indicating that the data collected was suitable for factor analysis. Two sub-scales, formed by combining several items were identified. The item "I have enjoyed attending the classes" did not load sufficiently onto either scale. Cronbach's alpha was computed for each of the sub-scales to provide a measure of the scale reliability. The sub-scales with their associated Cronbach's alpha values, and the names I assigned to them are reproduced and explained in the following sections.

Mathematical development scale. (Cronbach's alpha = 0.66)

In general my background knowledge has been adequate for study in this unit.
As a result of studying Mathematical Literacy, I have learnt to think in new ways.
My interest in the subject has increased as a consequence of this module.
I have gained more confidence in myself.
I would recommend this module to other students

Personal development scale. (Cronbach's alpha = 0.77)

I have grown and developed personally.
I have developed a greater sense of personal responsibility.

The scales identified above make "human sense" although it could have been expected that the item "I have gained more confidence in myself" might have fallen into the personal development subscale. Achievement on the personal development scale resonates with Marton's highest conception of learning, namely "changing as a person" (Marton, Dall'Alba, & Beaty, 1993), while the item in the mathematical development scale regarding learning to think in new ways is akin to the fifth conception, "seeing something in different way". These are higher conceptions of learning than are evident in preservice teacher comments regarding, for example, the acquisition of new knowledge.

The next part of the module evaluation, items 9 to 22, related to the lectures and the same procedure of checking the data and extracting the factors was followed. In this case, the Pattern Matrix indicated three components, with two items failing to load sufficiently onto any component, and one item loading on to two components. In the latter case, the item was included in the component where it had the higher loading. The three sub-scales identified are presented below with their associated Cronbach's alpha scores.

Lecturer expertise, clarity and enthusiasm scale. (Cronbach's alpha = 0.84)

I found that Mrs Hobden's lectures are well prepared.
I found that Mrs Hobden inspires enthusiasm for Mathematical Literacy.
I found that Mrs Hobden makes clear links between the sections.
I found that Mrs Hobden is willing to answer students' questions.
The use of sexist or racist stereotypes and examples has been avoided.
Mrs Hobden has been helpful to both female and male students.

Level of difficulty of work scale. (Cronbach's alpha = 0.55)

I found that I am always able to understand the language used in these lectures.
I found that the level of difficulty of the lectures is just right for me.
I found that the pace of Mrs Hobden's lectures is just right for me.

Culturally responsive class ethos scale. (Cronbach's alpha = 0.47)

Cultural differences amongst students have been acknowledged.
Provision has been made for students with language difficulties.
A class atmosphere conducive to learning has been maintained.

Neither item 9; "I felt confident Mrs Hobden cares about my progress" nor item 17: "I think that Mrs Hobden has a good relationship with the class", loaded onto one of the scales above. This could be because they are factors very specific to me personally, and not necessarily perceived as characteristics of the lectures. Neither item correlates very highly with any other item. Both of these items showed strong agreement with 83% of the students agreeing that I cared about their progress (45% strongly agreeing) and 88% agreeing that I had a good relationship with the class. The three subscales of the lecture section of the module evaluation can, to some extent, be matched to the five pillars of motivating instruction for adults suggested by Wlodkowski (1999), and discussed in section 3.4.6. The subscale "lecturer expertise, clarity and enthusiasm" encompasses the aspects of good lecture preparation, clear understandable delivery and the obvious interest and value the lecturer attaches to the subject described by Wlodkowski (1999) as the "offering expertise," "demonstrating clarity" and "showing enthusiasm" pillars. The "level of difficulty of work" subscale comprises three items related to the match between the demands of the course and the capability of the preservice teachers. This matches Wlodkowski's "having empathy" pillar which he contends is closely bound to knowing the students and making the work accessible to them. Finally, the "culturally responsive class ethos" subscale echoes Wlodkowski's "being culturally responsive" pillar since the items reflect a respect for diversity and the maintenance of a good learning environment.

The third section of the module evaluation, items 23 to 27, related to the preservice teachers' perceptions of the assessment practices used in the module. Exploratory factor analysis revealed just one component, and the Cronbach's alpha for the five items was 0.76 confirming the internal consistency of the five items in the assessment sub-scale.

Assessment scale. (Cronbach's alpha = 0.76)

Instructions on assessment tasks were clear and specific.
A variety of assessment tasks were provided.
I learned from the mistakes I made in the assignments.
Tests made me work harder than I normally would.
I think that the way my progress is assessed (assignments, tests, exam marks) gives a fair reflection of my understanding and ability.

The fourth section of the module evaluation questionnaire (items 28 to 34), related to effort and motivation. The seven items fell into two components, identified as sub-scales below.

Lecturer encouragement and motivation scale. (Cronbach's alpha = 0.70)

I have been motivated to do my best work.
I have attended classes regularly.
I have been encouraged to be responsible for my own learning.
I have been encouraged to work independently.

Personal effort scale. (Cronbach's alpha = 0.43 or 0.50 if item28 is deleted**)**

I believe that if I missed a lecture in this module, my understanding of the work would diminish

I feel that I have devoted an appropriate amount of time to studying this unit.

I have utilised all the learning opportunities provided.

I characterised the first scale as lecturer encouragement and motivation because three items were phrased so that the preservice teachers were in a passive role (being encouraged for example), and even the fourth, class attendance, was more lecturer controlled than it seems due to the module requirement of 80% attendance at lectures. The time spent on studies, and utilisation of the learning opportunities were student choices and hence these items formed a scale named the personal effort scale. A high agreement with this scale would indicate a person with a strongly positive disposition, as they would appear to be convinced that steady effort in learning mathematics would pay off, and the effort expended was worthwhile (Kilpatrick, Swafford, & Findell, 2001).

The fifth and final section of the module evaluation questionnaire consisted of three items (items 35 to 37) relating to the tutorials. The Cronbach's alpha for these items is 0.70 which indicates sufficient internal consistency. When considering the Item-Total statistics, the Cronbach's alpha for this scale would not be increased if any of the items were deleted, indicating that each item contributes to the overall reliability of the scale. The final sub-scale is:

Helpfulness of tutorials scale. (Cronbach's Alpha = 0.7)

I found that it was useful to bring problems that I have in lectures to a tutorial.

I found that the tutor was well prepared for tutorials.

I found that the tutorials helped me to understand the subject better.

There are thus nine sub-scales to consider. The scores for each scale were computed for each preservice teacher by averaging the scores of the items making up the scale, and then the mean score for the whole 2004 cohort computed for each scale. This is shown graphically in Figure 6.1. To assist in the interpretation of the mean scores which are levels of agreement, the sub-scales have been rephrased as single positive statements. The length of the bar then indicates the level of agreement with that statement. It should be noted that a score of 3 indicates a neutral response, a score of 4 indicates agreement, and a score of 5 indicates strong agreement.

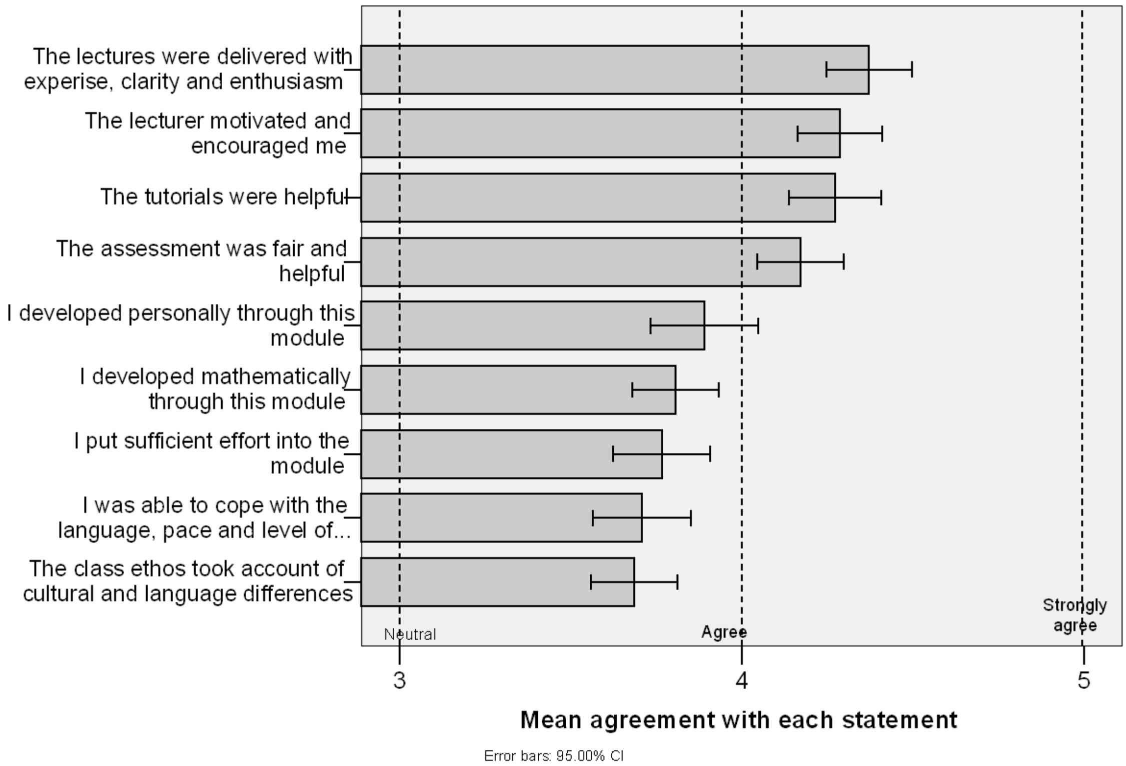


Figure 6.1 Mean agreement with each sub-scale of the module evaluation questionnaire. The bars depict the standard error of the means.

The overall picture presented by Figure 6.1 indicates positive sentiment for all scales as the means are all on the agreement side of neutral. Clearly, though, the extent of the agreement differs with some means not reaching the agreement value of 4. The scales relating to the input of the teaching staff (myself and tutors) and module organisation had the most positive means, while there was less agreement with those relating to their own development or input. The exception to this is the scale relating to cultural responsiveness which is a teaching staff responsibility, and which had the lowest mean agreement. Each of the sub-scales will be discussed in turn, supplemented with additional data from the free responses made on the module evaluation questionnaire, the independent QPU report, the preservice teacher interviews and the reports of the tutors.

A one way ANOVA was used to explore the relationship between the scores for each component and the identified groupings such as gender, race, type of school attended school mathematics background. The ANOVA determines whether the differences between the specified groups are significantly larger than the differences within the specified groups. This was the case when the relationship between the "level of difficulty" aspect of the lectures and the race of the students was explored. An F-ratio of 3.01 with p=0.03 was obtained (see Appendix V). This means that with 97% certainty we may conclude that the computed variation in scores for agreement with the statement "I was able to cope with the language, pace and level of difficulty in the lectures" scale between the race groups is three times as great as the variations within each race group. The African students' mean score was calculated to be 3.6 which when compared to the mean of 4.2 for the white students points to the problems African students might have had with the pace, level of difficulty and language of the lectures. There were no significant differences in the mean scores between gender, race, type of school attended and school mathematics background for any of the other scales.

General section of the module evaluation

The two subscales from this section were named mathematical development and personal development, since the items in the first seemed to relate more to the module content, while the items in the second scale related to personal growth.

Mathematical development. Considering the five items that made up this scale, a score of five for any individual in this scale would indicate a person who strongly agreed that they came into the module with an adequate background for the demands of the module, learnt to think in new ways and developed an interest in the subject resulting in increased personal confidence and a willingness to recommend this module to others. The mean score for the agreement with the summarised composite statement "I developed mathematically though this module" was 3.81which is close to the agree category value of 4. Consideration of the individual items yields some useful insights.

Only 44% of the preservice teachers agreed that their background knowledge had been adequate for study in the MLE module, or as reported by the QPU "26% thought that they did not have an adequate background knowledge and 30% were not sure if they did" (QPU Report, 2004). Preservice teacher comments made in reference to the difficulty of the module allude to the awareness of students that even within the cohort, their mathematical backgrounds were different, and time lapse since schooling exacerbated the problem. *For me it was difficult. I left school in 1998 so I stayed at home for 4 years. And I can say that the last semester was so hard for me. So I try my best to work hard and I made it in the end. But at the beginning it was too hard. Now, I remember the first test. I failed it with flying colours. And I cried. And another student was so happy. And I didn't know what was expected. So, by the time goes it was fine* (Senzeni, interview).

Unlike the mathematical content achievement which was assessed by the course mark, the less tangible achievement of opening up new thinking possibilities was self - assessed. Eighty nine percent of the preservice teachers agreed that they had learnt to think in new ways, 5 % were neutral and only 6 % of those answering the questionnaire disagreed. This was endorsed by Gloria who wrote *I think everybody must have to start in Maths literacy, even though they have pass maths in Matric, because this one really open your mind*, and Masimezi's commented: *I experience to think critically about things. I learn to use numbers very well beside using machines*. Elaine wrote *It helped me achieve a better understanding on most of the topics covered therefore rendering me more confident in my future use of maths*. Only 55% of the preservice teachers agreed that their interest in the subject had increased and for some it was simply more of the same as indicated by Thandi's response to my interview question as to whether her feelings towards mathematics had changed: *Maths will always be Maths, so whether it's varsity Maths, primary Maths high school Maths- it will always be Maths. So obviously as you grow older your feelings tend to change a bit you know and as a teacher…you have to have an understanding of what you're doing whether you like the subject or not.* And some just thought it a waste of time: *I think this course is totally unnecessary to us, especially when you don't plan on using it, though Mrs Hobden is a great lecturer* (Anonymous). This sentiment was presumably shared with the 10% of preservice teachers who indicated that they would not recommend this module to other students.

Personal development. This scale was made up of two items and a score of five in this scale would indicate a person who strongly agreed that on personal level, they have grown and developed and achieved a greater sense of personal responsibility. The mean score for the agreement with the summarised composite statement "I developed personally though this module" was 3.89 which is close to the agree category value of 4. While only 7% of the preservice teachers indicated that they disagreed that they had grown personally, 21% were neutral which could indicate that they were not sure. Seventy five percent agreed that they had had achieved a greater sense of responsibility. *I've enjoyed doing this course. It has brought back my love of Maths. It has built confidence in me. It has helped me learn to work on my own* (Benisanani). Rubin and Senzeni both endorsed this when they wrote *It has helped me to try and understand maths and also helped me to be confident in my daily life activities* and *I have experienced to work independently and asking if not understandable.*

Lectures section of the module evaluation

The three sub-scales revealed by the exploratory factor analysis of this section of the module evaluation relate in turn to the lecturer, the demand of the work and the class learning environment and ethos.

Lecturer expertise, clarity and enthusiasm. This scale had Cronbach's alpha=0.84, indicating a high consistency. It was rephrased as the single statement; "the lectures were delivered with expertise, clarity and enthusiasm", and this was accorded the highest agreement score (see Figure 6.1) with a mean of 4.37 which is approximately halfway between the "agree" and "strongly agree" categories. In other words, the preservice teachers, on average, leaned towards strong agreement that the lectures were well prepared, delivered clearly and enthusiastically and in accordance with principles of non-racism and non-sexism. This sentiment was captured by Xolile who wrote that *the lectures are knowledgeable, understandable, clearful (sic), and helpful to me as I had no knowledge before I studied Maths Literacy.* There were several comments that the lecturer treated all students equally. Faye wrote that *Mrs. Hobden was good to all the learners whether you white or black* and Prisca said that, according to her point of view *these lectures were very good…they don't care what colour you are*. The school experience of many of the preservice teachers was characterised by abusive and inconsistent teaching (see Chapter 5), making the comment *Mrs Hobden is always in the same mood* (Nokuphiwe) seemed particularly poignant to me.

Language, pace, and level of difficulty of lectures. This scale was a composite of three items related to the language, pace and level of difficulty of the work, replaced with the positively worded statement: "I was able to cope with the language, pace and level of difficulty in the lectures." The mean agreement score for this statement was 3.70 making it the second lowest ranked statement, and not up the agree score of 4. It is important to note at this point, that the module evaluation was completed at the very end of the module by which time many of the preservice teachers who had experienced the most difficulty had abandoned the module and were no longer attending the lectures. For this reason, I consider the mean score on this scale to be an overestimate of the sentiment of the entire cohort.

Caution must be exercised in the interpretation of some items. For example, as the QPU report pointed out, the mean of 3.10 for the item "I found the pace of the lectures just right for me", conceals the fact that 27% disagreed with the statement, and 31% were neutral. Furthermore, it is not known whether those who disagreed did so because in fact the pace was too slow, or because it was too fast; nor whether the neutral responses indicate uncertainty or a mixed response (sometimes fine, sometimes too fast, sometimes too slow). Evidence from the open responses and interviews does, however, support the position that the weaker students found the pace too fast, especially in tests. For example, Venetia wrote: *Mrs. Hobden is very fast, sometimes I end up didn't hear a word. I can say she knows Maths (over) but cannot let me understand the way she understands it* and Bathabile wrote: *if only she can slow down the pace of how we writing a test e.g. not to quick switch computer or laptop while we writing a test or mentally calculation.* Neither of these preservice teachers passed the module. Others though found the pace too slow, and commented that for them personally, *more work could have been done in one lesson, and not so spaced out* (Anonymous). The misunderstanding of language is evident in the following comment, presumably a misinterpretation of the item related to the pacing of the lectures: *I think the lectures are spaced apart correctly except for Friday I do not think that it is the right thing to learn maths in the afternoons* (Themba).

Only 9% of the preservice teachers disagreed that they were always able to understand the language of the lectures, with a mean agreement of 4 (agree). Nkanyiso, however, hinted at language difficulties when he wrote that he had *no experiences in mathematics but I can manage if I can put more pressure in my English improvement*. He unwittingly provided further evidence of language difficulty as his response to being asked to describe his experience in the MLE module was to begin by stating that he had no experiences in mathematics, indicating that he had missed the meaning of experience in that context. In an interview, Sele informed me that *among us they are those who come from the rural, deep rural areas and you know when it comes to express themselves…they feel difficulties because the way they are taught in school…they are taught English in Zulu, other subjects in Zulu you know* and added that this might explain why some students *don't understand at all - they just sit there and stare at you not understanding what is going on.*

In other cases it was not clear whether the difficulty in understanding mentioned by preservice teachers was due to the cognitive demand of the mathematics content, the pacing or the language. For instance, Vuyisile wrote that *lectures sometimes help us as students if we have difficulties but we need more time on studying maths because it* *sometimes a difficulty (sic) subject* and Nompumelelo commented: *sometimes I didn't understand what the lectures explain.* A very common frustration expressed by mathematics learners at all levels is their feeling of knowing the work during the lectures and supervised practice, only to find themselves at a loss at home or in a test when working on their own. The comment made by Patricia typifies this frustration: *The lesson is still running right and it is still understandable except that sometimes we done the easy work to the class and while it comes to homework we given difficult work that we can't cope with.* The same problem is expressed by Siwe in the following interview extract:

Siwe *All these activities we used to do in the classroom…You know I can easily do it myself but when it's come to test, eish, I don't know where to start, what to do. I can say that's my big problem and sometimes I can't understand what really the question is looking for, what's expected to do.*

Interviewer Ok. Now do you think that's a problem with the English language? Or a problem with the Maths language?

Siwe *It's the Maths language. Because then I think I can look at the sum in the classroom and when I'm trying to study at my home, ay it was like woah, woah, I really forget what was, how did they do this, how did they get this answer. When we are in the Margaret Martin (lecture theatre) you know I can see you doing everything there and I can try to do it myself but when it come to the test hey I fail it.*

Interviewer Well, when it comes to the test you're on your own. So do you get worried and nervous in the test do you think?

Siwe *Ja I just get worried like when I get the question paper just look some of the sums ok it's ok I know this one, I know this one, oh I forgot this one then I just get scared because I know I'm losing some marks there now.*

Neither Patricia nor Siwe passed the module.

Culturally responsive class ethos. Two of the three items in this scale related to the acknowledgement of cultural and language differences between students and the third to the maintenance of a good learning environment. Together they formed the composite statement: "The class ethos took account of cultural and language differences." Like the work scale discussed above, this had a mean of 3.69 indicating only weak agreement. Although, within another scale, the preservice teachers on average agreed strongly (mean = 4.6) that there had been no racial or sexist stereotyping, and that I had been helpful to both genders (mean = 4.5), there was considerably less agreement that cultural differences and language difficulties had been attended to. The relatively large percentage of neutral responses (29% for cultural differences and 39% for taking account of language difficulties) could indicate that these were not seen as issues, or that these were not seen as a feature of the module. It would be unwise to infer that all the non-positive responses indicated a perception of deficit in this area. There were very few written comments supporting the lack of cultural responsiveness - only an anonymous observation that all the tutors were English speaking and the suggestion that some Zulu speaking tutors should be employed. Olwethu, however, brought up the issue of cultural differences in the interview when she spoke of the reticence felt by young people in the Zulu tradition towards questioning older people: *Ja now I don't have the background… I need someone to help me to remember…I need to ask some questions when you teaching but ah I'm scared because you know … in our culture it's not easy to give the person if she or he's older than you many questions now I'm scared to ask you "I don't understand that part" and I'm scared of many learners in the class.* Although this was noted as a problem in the lecture situation, Olwethu did go on to say that the tutorials had provided an opportunity to speak more freely.

The mean agreement with the item relating to the maintenance of a class atmosphere conducive to learning was 3.8 which is below the agreement level of 4. Only 8% of the preservice teachers disagreed that the class environment had been conducive to learning but there was a substantial percentage (24%) who were neutral. The class size of 142 in a large lecture venue was mentioned as a reason for insufficient lecturer attention to individuals (Anonymous) but Leon felt that despite the fact that *the main class is way too big…somehow a learning atmosphere is pretty well maintained.* The disruptive behaviour of some students who chatted through the lectures and left early was noted by preservice teachers such as Linda who wrote that *other students walk in and out while the lecture continued was the only problem and this doesn't motivate me* and Phiwe cited the noise made by some students as the reason why *it was not easy sometimes to understand what is going on in class*.

Assessment section of the module evaluation

Each of the five items that made up the assessment scale, summarised as "the assessment was fair and helpful," had a mean score of over 4, indicating moderate agreement with the positively worded statements. Overall, the mean score on this scale was 4.17. There was general agreement (by 78% of the preservice teachers) that the assessment of the module had been fair, that a variety of assessment tasks had been given (86%) and that the preservice teachers had learnt from the mistakes they had made in their assignments (85%). It should be noted however, that this data was collected before the examination which was half of the assessment mark. Some preservice teachers found the assessments enjoyable as evidenced by comments such as *the tasks were fun and challenging* (Estelle) and *I enjoyed doing my assessment* (Muriel). On the other hand, the memory of the mental arithmetic test remained vivid for some eliciting remarks such as: *the look and write test was a nightmare for me and led to me failing the test which is unlike me* (Nokuphiwe) and *the test on estimation was a nite mare (sic) for me!* (Njabulo).

Although many preservice teachers welcomed the multitude of assessment tasks as a way to build up a good class mark and as *an opportunity to raise up my marks* (Ntombifikile), others found it difficult to work outside of the lecture time. The extract from an interview with Nhlaka, reproduced below, gives a clear picture of the type of family responsibilities and social pressures that hinder the learning of adults. *It was a basic for me because I did Maths on higher grade, but I feel that I didn't give my all in it because I know that I would have done better in it if I gave it my all. There are some assignments which I didn't finish. Like the one that you gave with the graph, the project. I didn't finish it. I don't know why I had all these problems. I wanted to speak to the counsellor because I like working with numbers, but when it comes to assignment or something I can do in my own time, I can't finish that thing. I don't know exactly what's my problem because sometimes I stay in Umlazi, so I can't do anything and I'm very busy. My brother runs a tuckshop so when I come from school I work at the tuckshop and during the weekend I also am in charge of the tucksho*p. When asked if he had a place to study, Nhlaka continued: *No actually, I don't have a place. So I have to do all my schoolwork here. If I didn't finish, it's a problem…. I am starting to realise that I must finish my work here because at home I don't have time for it. If I have, someone call me to be somewhere then I start to feel lost*.

On occasion, the assessment activities were marked by the tutors and there was some dissatisfaction over the marks allocated, especially when comparisons were easily made because the work had been done in groups. This was unfortunate because it worked against a productive disposition towards the subject. For example, Bathabile claimed that the *assessment of assignments was totally bad as we do some of our assignment into groups and you'll find that others got high marks than we have* and Rachel complained that *sometimes the student tutors did not give me a fair reflection of my work*. It was disappointing to find that Masimezi was so discouraged: *I do every assignment but only to find that the lecturer does (sic) not satisfied with my work then I become confused because I've wasted a lot of time dealing with it.* Other complaints were more administrative, for example *they said I missed a lecture but I do have a doctors document* (Nkanyiso) and *assessment were not really fair because sometimes we handed in work and when they bring it back we were told that we did not hand it in, our scripts were missing* (Wilson). Although only 9% of the cohort disagreed that the instructions for assessment tasks has been clear and specific, there was some mention of confusion surrounding the assessment tasks, particularly the statistics project. It is not clear whether comments such as *sometimes I really confused about assessment cause (sic) I didn't know where I must start* (Nompumelelo) and *assessment we given is very difficult to understand although tutors help us during their time and we do get a little bit clue* (Patricia) point to difficulties with the mathematics content or the language and clarity of the instructions provided.

On a more positive note, Rubin noted that *Mrs Hobden was very helpful and motivated us with her…comments after marking our work* and Nontokozo wrote that *assessments made me see my mistake*s. There were also comments to support the relatively high mean agreement (4.2) that tests made the preservice teachers work harder, for instance Malcolm felt that *the assessment was very good and I have been working very hard than normally* and Rejoice concurred writing: *Maths literacy has many assessments which cause us to work harder*.

Effort and Motivation section of the module evaluation

The two subscales revealed by the factor analysis related firstly to the encouragement and motivating influence of the lecturer, and secondly to the personal effort and self motivation of the preservice teachers themselves. These will be discussed in turn.

Lecturer encouragement and motivation. The mean agreement with the composite statement for this scale: "The lecturer motivated and encouraged me", was 4.29 making it the second highest ranked statement. There was strong agreement that the preservice teachers had been encouraged to be responsible for their own learning (only 2% disagreed) and that they had been motivated to do their best work (only 4% disagreed).

The motivating influences seem to have been the enjoyment of the lectures and the response to a caring attitude on the part of the lecturer. A preservice teacher wrote that *it was fun and you wanted to do well because of all the interesting facts and games and tasks* (Anonymous). This view was supported by Gloria who claimed that *the class has been enjoyable and we have been looking forward on what we will do nex*t and Theresa who said *I was excited to go to all classes because of the lively atmosphere*.

Given the negative attitudes towards mathematics evident when the preservice teachers entered the MLE module, statements such as: *It was motivating to do my tasks etc, I wanted to do well!* (Karen); *Mrs. Hobden made me like the subject that I once hated with a passion so I was motivated to at least try to do well* (Zaheera) and *I was motivated by Mrs. Hobden and tutor I was try to make the best in work (sic)* (Ntombifikile) represent a much improved attitude. Other preservice teachers noted that they were motivated because of lecturer care and interest, writing for example, *I was very motivated…Mrs. Hobden is very interested in helping us* (Xolile) and *I was motivated a lot, so I always came to class. It was good to know someone cared* (Rathun).

Some of the lecturer's motivating influence was directed towards encouraging the preservice teachers to take responsibility for their own learning and this drew comment from several of them. For instance, Msawkhe claimed *it real motivated me, to be self disciplined, punctual and responsible for my work.* Benisanani wrote that *because of the motivation by Mrs. Hobden, I have managed to work very hard as well as independently in this course* and the comment *it helped me to take everything seriously and be responsible for my own life* was made by an unnamed preservice teacher. Msebenzi put it simply: *I was told to try to do things on my own and that is what I did.*

Preservice teachers' own effort and motivation. This scale had two closely connected items related to devoting an appropriate amount of time to work in the module and utilising the learning opportunities, and the third item was to do with whether missing a lecture would impede the understanding of the work. The last mentioned item, was excluded from the analysis as the Cronbach's Alpha was improved by its deletion. The scale was summarised by the single statement: "I put sufficient effort into the module," and the mean agreement with this was computed to be 3.77 which is somewhat less than the agreement value of 4. There were a lot of neutral responses to the two items (about 27% of the cohort in both cases) which could indicate an unwillingness to commit, or uncertainty, ahead of the final examination, as to whether the effort had in fact been sufficient. Data from the free responses on the module evaluations and the interviews were more enlightening.

With the notable exception of Venetia who stated quite clearly that she was *doing this module because I was forced, it is not what I planned or liked*, most of the preservice teachers claimed that were motivated to try their best, but some felt discouraged in the end. Verna wrote *I was motivated but the thing is Maths is too difficult* and Rejoice too claimed to be motivated *although I found that mathematics is difficult because I have no* *background with it* (module evaluations, 2004). Others appeared even more defeatist writing *I have tried my best, but I couldn't done (sic) my work properly. Maths is not my subject. I am clear about that* (Busisiwe) and *I tried by all means to do my work but I failed I don't know why* (Nompumelelo).

Masimezi had an optimistic attitude as evidenced by his remark *I always try my attitude to be always positive even I obtain bad marks and I told myself that I will do well next time*. Thandi and Menzi both claimed to have made a good effort writing *It took time to be disciplined in order for me to be motivated. But I grew to put more effort in every thing I did* and *I made such great effort to study more. I never used to study and in this module I was motivated to study more often*. And Bheki stated succinctly, if ungrammatically: *More effort I putted*.

Despite good intentions, it is evident, for example, from the extract from the interview with Nhlake reproduced in the assessment section above, that there are constraints on the efforts preservice teachers are able to put into their work. Many of the preservice teachers interviewed were critical of their peers who were battling, and indicated their opinion that it was their own poor attitude and laziness to blame. John, a student who had done all his schooling in Afrikaans, overcame the language problem and did very well in the module. When asked why he thought some of his peers had difficulty with the module he replied:

John *I think most of them, like some of the Indian people, I have looked at some of them, they just bunk classes, sign the register and go. I think that might be the case. They won't pay attention. It's not that hard. It's easy if you pay attention.*

Interviewer So do you think that people just don't put the time in.

John *Some of them just didn't show any interest. I think they just don't care.*

Interviewer It's quite expensive really, not to care, because if you do it again, it's another R1000.00.

John J*a, they are wasting all their money. They paid that amount and don't pay attention. They do it in other lectures as well. I don't know how they pass. Because I spoke to some of them and asked them if they were ready for the exam and they said they can't write, they lost their DP's because they didn't go to the classes. (Interview, 2004)*

Leon contended that the *one thing… that really helps more than anything else is paying attention in class. That's the number one thing.* When asked about the reasons he thought other students struggled, he suggested that *maybe their educational background had something to do with it but I don't see that as the sole reason. Maybe they had an* *attitude in which it is difficult, it will stay difficult and not bother to put that much more effort in to make it easier* and continued: *I saw a lot of people that really wished they were somewhere else to the point that they just didn't care what was going on in class in the first place. I mean, that affected their marks. They just wanted to get out* (interview). Sele supported this view of students in the lectures, as indicated by the following extract from an interview: *I don't know they seem to be bored and the stigma that is put to Maths, some of them say "Ag Mathematics I didn't do it at school why now?" You know they just don't like Mathematics and you know lack of responsibility and discipline….you know I think basically it's that because I don't think it is the student are not bright and don't have the capacity…to do Maths Literacy but I felt that there was a lack of responsibility and some of them didn't practice at all….They would come to the lectures and sit and sign the register and go out. But for us, my group, you know we used to stay even if we feel "No eish we are tired" but we stay and you know persevere for the whole lecture then we go out*.

Sele came up with the idea of organising study groups for students who needed both encouragement and academic help. What follows is her vivid description of how she would organise it and the resistance she envisaged:

Sele *I think one thing that can help them is the workshop not the counselling thing because most of us don't believe in counselling as blacks, you know we don't believe in going there….If we can maybe help (with) workshops, maybe in groups of 20 you know, be told and we share our experiences… Maybe we revive and motivate others and say "No guys you know I didn't pass my Maths but now I'm doing well and you can do it also." Everyone is for himself or herself here. If you can't think that you must form a group then you're on your own and maybe you have a real difficulty and maybe you are shy to ask. That is some problem that I realise…because I am an open person some will come.*

Interviewer You'd sort it out?

Sele *Yes ,yes. They will say "come come and help me" and I say "No you must join the group and you know some of them are lazy you know "Eh I didn't know 8 o'clock we meet" but when the time comes they won't come - they'll watch Generations* (a popular soapie*). One, one, one they won't come, they won't come.*

Perhaps the best expression of a productive disposition came from Phiwe who explained his philosophy as follows: *When time goes on I say, this thing I can pass this thing, because if you go to the tutors and they explain and Mrs Hobden is trying to explain first, then how can I fail it because I've got three possible things here. First, I have to work* *hard for myself, Mrs Hobden and the tutors. So there is nothing that can stop me from passing* (interview). And indeed, he passed with 58%.

Tutorials section of the module evaluation

The composite statement for the three items making up the tutorials scale was: "the tutorials were helpful", and the mean agreement with this statement was 4.3 indicating moderate to strong agreement. Only 1% of the preservice teachers who completed the module evaluation disagreed with the statement that the tutorials had helped them to understand the work better. The comments made about the tutorials reveal that the preservice teachers valued them for three main reasons: (a) the tutors helped with re-explaining work dealt with the lectures; (b) they provided a safe space to ask questions and; (c) the good relationship with the tutors was an encouraging influence on the preservice teachers and an inspiration to do better.

It was my intention that the tutorials should provide opportunities for the preservice teachers to make sense of the work, and indeed many of them remarked that the tutorials had been instrumental in developing understanding. Smangele wrote: *they were great, just what I needed after the big class lecture and to have someone to explain things in details, individually* and Praise commented that the *extra classes we had were very helpful to me, sometimes I found some difficulties in a class but when I go to tutorials, all of my problems were solved.* In the interview, Lindane spoke highly of the value of the tutorials saying: *The tutorials were very helpful. Kirsty and Debbie, in particular, if I can mention the two of them, were absolutely wonderful. They did a wonderful job and I commend you on choosing them to be tutors for the tutorials because they worked with you in the difficulties that you experienced. They started from scratch. They had the patience and understanding and even trying to give you simpler solutions to the problem.*

The large size of the group in the plenary lectures in the Margaret Martin Lecture theatre (MMT) seemed to be daunting for some of the preservice teachers who expressed the feeling that it was easier to ask questions in smaller groups. This is illustrated by the following extracts from the module evaluation comments: *Tutorials were very good because I was able to ask what I was scared to ask at MMT. They help me a lot because I was struggling with this course* (Cinnie) and Muriel's comment: *I felt very welcomed by my tutorials and I was willing to ask anything I didn't understand*. As mentioned in a section above, Olwethu contended that another barrier to asking questions in the large venue was the perceived disrespect this would show to me as an older person. Later in the interview she spoke of the fear of asking in a large group where her peers might be impatient. An edited version of the interview transcript is reproduced below:

Olwethu *I'm scared to ask you "I don't understand that part" and I'm scared of many learners in the class.*

Interviewer There were many.

Olwethu *Ja there were many and now I'm scared to ask many questions but when you divide us to these small groups, oh, you give me the biggest chance to ask. I was doing the small classes with Matthew, Matthew is very very ... I don't know how can you explain, but he is very active, is very friendly with the learners. I don't say you are not friendly with the learners but because I follow their instruction of our culture now it's not easy to ask if...*

Interviewer Well he's much younger than me too

Olwethu (Laughs*) But I do think the learners are too, too, too many and now I'm scared to ask to ask questions. Maybe they say "Eh you're stupid - you're wasting our time." I'm scared of those things now when I've got the small group I've got more chance to ask "Please Matthew come here. I don't understand this, how can you get this answer? If I'm doing like this I get this answer. Is ok? ...To have a small groups it helped me lots.*

The preservice teachers had high praise for the tutors who had treated them with kindness and respect. Nkanyiso and Prisca both commended Debbie writing: *Debbie! She is so nice and politely toward us. She teach very nice* and *Debbie, it was unbelievable that she know each and every student's name. I was very shocked to see that. Without them I'm nothing!! I love you all*. Venetia wrote that *John was sent by God to us, he is very helpful and nice to all student in his tutorial class.* This positive relationship resulted in the preservice teachers feeling encouraged and motivated. For example, they wrote that the tutors were *very helpful to me and encourage me to do best and help me in my problems* (Ntombifikile) and *they were caring and understanding of your problems. They encouraged you to do better* (Thandi).

It must be noted though, that some of the preservice teachers, notably the more able students, did not feel the tutorials had benefited them, mainly because their *understanding of the subject was pretty good with the lectures alone* (Leon) and they felt they *didn't need any extra tutorials* (Jennifer). This is in keeping with the previously reported result (see section 6.2.1) from the "How are you doing" questionnaire where six of the more able students indicated that they were managing well without help from tutorials. Other objections included a preference for more content: *tutorials were a waste of time. I* *would've liked more theory lessons* (Estelle) and a preference for the lecturer to explain the work: *I found it easier to understand the work in the classes with Mrs. Hobden. The tutors did not explain the work very well* (Rachel).

6.2.3 Co-worker insights

The four tutors, (senior mathematics education students), who conducted regular formal tutorials, and occasional informal tutorials as part of their own studies, were required to submit to me weekly reflections on their experiences with the group. These were done on a regular basis by John, Kirsty and Debbie, but Matthew who was experiencing personal problems at the time, fulfilled his tutoring responsibilities but only submitted the weekly reflections at the very end. I am consequently not confident that they represent authentic comment on events as they unfolded because there was a strong possibility that they were retrospectively written.

Following a process of coding using NVivo software, five dominant themes emerged from the weekly reflections of the tutors, written over the twelve weeks of the MLE module. These were (a) the general lack of disciplined study habits, (b) the language difficulties experienced by the preservice teachers, (c) the lack of basic arithmetic skills, (d) the lack of confidence and poor self efficacy beliefs of the preservice teachers, and (e) the improvement in motivation and engagement with the work over the course of the module.

The tutors observed from the outset that the lack of efficient study habits added to the general confusion about the content of the subject material and the failure to work independently on the lecture material prior to the tutorials was hindering the progress of the preservice teachers. Kirsty wrote that she could see that: *students are not attempting to do the extra practice examples and are not going through their notes individually to try and make sense of what is going on…they are waiting for the answer to go to them* (Week Three reflection). This continued throughout the module and later in the module John noted: *Once again the fact that the students learning, for the most part, ends were they stop writing on a Monday and Wednesday (the plenary lecture days) was highlighted. There were only four learners that had completed all the work on the worksheet* (Week Seven reflection). This lack of preparation, and seeming helplessness contributed to the next unacceptable study habit - that of cheating on even unimportant formative assessment activities such a practice mental arithmetic test. Debbie reported that one of the difficulties with the lesson was that of cheating as despite the requirement that the calculations be done mentally *many of them continued to write on their hands and use their phones and* *calculator* and John too noted that *they were blatantly copying from each other and often checking their answers with peers and on calculato*r (Week Six reflections). Perhaps what appalled the tutors most was their perception of the disorganisation of the module files presented for assessment during the first test. All that was required was to have the various sections of notes neatly filed in some coherent order, but all the tutors noted their shock at the disorganisation present in many files. *Another task, which we had to carry out, was the marking of the files. I was shocked to see how many students did not posses a file. I was also amazed at the state of many students' files. No order, notes not punched, torn notes and blank spaces was very common. If their files are not up to scratch then they will not be able to study properly which will result in bad marks. I thought that by allocating marks for files, students would be forced into organising their maths literacy notes. I was wrong* (Kirsty, Week Four reflection). On a more positive note, Debbie after also noting that *a few of the students simply had an exam pad, in which they had placed all their notes*, remarked that she was *surprised to see how many of them actually had good, organised files, with all their notes filled in* (Week Four reflection, 2004). The differences in study habits between students was marked.

The second theme, strongly evident in the weekly reports of the tutors, was their observation of language difficulties experienced by some of the preservice teachers. The nature of the language problem was not always clear as issues of pronunciation, general confusion over tasks and difficulties with the subject content knowledge can appear to be language problems. Early in the course, Kirsty reflected that *some of the problem lies with me in the pronunciation of the different decimals. The students were confused or maybe could not decipher the difference between one tenth and one ten, as they do sound very similar when spoken* (Week Two reflection). Likewise, when as was often reported, some of the preservice teachers were at a loss as to what to do, it could have been the language of the instructions or the perceived complexity of the mathematics. Debbie however felt it was a language problem, writing: *Many of the students have a problem identifying what is expected of them…rather than a problem with the maths. I feel that this is a language barrier, as the students do not understand the instructions* (Week Seven reflection). This view was supported by Kirsty's observation that *a difficulty that students had with the test… was language. They could not understand what was expected of them* (Week Four reflection, 2004).

On analysing the weekly reports, fourteen passages were coded as indicating the tutors perceptions of lack of basic arithmetic skills, making it the most dominant theme.

Week Two was the first time the tutors worked on their own with their group of students and they were rather taken aback at the lack of skills evident as the following comments from their reflections indicate: *I have found that the number sense of many of the students is very poor* (Debbie); *the learners are obviously quite weak at basic maths…I literally had to explain hundreds tens and units - Grade 2 mathematics!!!!!* (John); *what I found most difficult, frustrating and disturbing was the fact that so many students lack in basic computation skills* (Kirsty) and *the notion of hundreds, tens and units was very confusing for the learners…it appears that this mathematics principle taught at primary school means very little to my class* (Matthew). Each subsequent week's reports contained specific examples of poor arithmetic skills such as failure to recall simple multiplication facts, misunderstandings of place value and idiosyncratic use of mathematical notation such as described by Debbie: *One student kept on using brackets incorrectly … if the question was 56x4, she wrote 5(6+4). The student did this for every question* (Week Six reflection, 2004). As they interacted with the preservice teachers, the tutors began to realise the legacy of disadvantaged and dysfunctional schooling that some of the preservice teachers carried: *Language as mentioned before also serves as a huge problem. In helping a student in the library, he told me that he does not understand many of the words I say because he was taught maths in Zulu at school. He said his teacher used to hit him and he was just so terrified and hated maths so much because of this. I really felt sorry for him* (Kirsty Week Two reflection).

The poor self efficacy beliefs of the preservice teachers were evident to the tutors who remarked that they were not *comfortable enough in their own ability, may be embarrassed to make mistakes in front of other learners, and need to be encouraged so as to boost their own confidence* (John, Week Two reflection). This lack of confidence hinders progress as Matthew explained: *When I come around to assist struggling students, they stare blankly at me, not knowing where to even begin. When the one method that they think works fails, then their confidence is shattered and they just stop working. I think this is indicative of the problem with maths generally. Once the standard procedure fails, learners are too fearful to try again, and it is this fear that ultimately ruins their ability* (Matthew, Week Three reflection).

When it came to the test, Kirsty reported that many of the students were extremely nervous and that she had *heard a group of students saying that they were going to fail even before the test was written. This negative feeling towards the subject needs to change so that students start to believe in themselves and do well* (Week Four reflection). As the module proceeded there were reports of a more positive nature, notably of increased enjoyment of mathematics and more productive dispositions.

One of the aspects of a productive disposition towards mathematics is the belief that steady effort at mastering the work is worthwhile, and this became evident when the preservice teachers were asked to solve Maths 24 cards as an exercise in recording the correct order of operations. All the tutors reported this as a successful lesson with the preservice teachers engaged and motivated to the extent that *I had to force them to leave at the end of the lesson!* (Debbie, Week Five reflection). *I observed how the students tried many different ways to reach the answer of 24. They were really determined to get the cards correct. One particular student spent almost the entire time allocated tackling one specific card, which had three dots. (It was difficult) When he eventually arrived at the answer he was so happy and satisfied. He never gave up even when I told him to try another card, which was a little easier* (Kirsty, Week Five reflection). Other more relaxed activities such as creating and peer -assessing basic statistics posters attracted effort and were also enjoyed by the preservice teachers and the tutors alike. Evidence of this is found in the following comment written after Week Nine: *After marking their posters, it is clear that many of them put in a lot of effort….I could see that many of them actually enjoyed making their posters….I enjoyed taking part in this session as the students really enjoyed themselves and it was rewarding helping them learn* (Debbie).

In contrast, when put under pressure to do calculations in a prescribed way and under time constraints, the old negativity returned as noted by Debbie: *Many of the students were very negative about this section of work, and I heard a few comments such as 'This is why I hate maths' etc. It was therefore difficult to keep them motivated and interested. I felt that the students were more positive when they were able to use their own methods, rather than a method prescribed to them* (Week Six reflection). The tutors reported improved attitudes towards mathematics as the module proceeded which they found *very heartening, as it shows that the process has been a success* (Matthew, Week Six reflection). Matthew continued to cite examples of two students who had made good progress: *As they gain confidence, their ability is increasing…Students like Simon and Lizelle, who have categorically stated what they think about maths. are now amongst the top students in the set*. Kirsty too, was heartened by the affirmation she got from a student she helped: *One student came to me today and thanked me for my help in preparing her for the last test. She said I really helped her and because of it she did well in the test. I really* *felt good about this. (Just thought I would share this with you) I am really enjoying doing these tutorials* (Week Five reflection).

The weekly reports were an invaluable source of information for me as the module unfolded, as they gave me insights into the 2004 cohort of student and it was clear that the tutors themselves had learnt a good deal about teaching and learning mathematics. The opportunity to work with senior students in this way was unfortunately a once-off occurrence because the module would not required in the Bachelor of Education programme in future, and new ways had to be found for the year ahead.

6.2.4 A way forward for 2005

As in the previous year, while the way forward for the next cohort was being considered, an opportunity presented itself. The university received some unexpected donor funding into the SANPAD University of KwaZulu-Natal Access and Retention (SUKAR) project. Consequently, a call was made to the University community to put in proposals for programmes aimed at improving access to tertiary education, and more particularly retention beyond the initial access support. Although not strictly an access module, I felt that the MLE module might qualify for assistance as it was a barrier to mathematically under-prepared students who had nevertheless managed to gain entry into the university. A proposal was drawn up to provide resources for the preservice teachers to work independently to master the content of the MLE module. The proposal (see Appendix T) was accepted and so the plan of designing a self-help CD to accompany the lecture material, buying a small collection of adult focused basic mathematics textbooks for loan, and videotaping the lectures for review purposes could be put into place for 2005.

6.3 THE STORY OF THE MLE MODULE - PART THREE
2005 - INTRODUCING RESOURCES FOR SELF-HELP

The entrance requirements for the Bachelor of Education in 2005 were raised and a decision was made not to admit students without a matriculation exemption. Consequently, I expected fewer students for the MLE module, and indeed the numbers were considerably down from 2004, settling at 69 students. Perhaps the most marked difference in this cohort was that 58% of the preservice teachers had complete matriculation exemptions (up from 18% in 2003, and 24% in 2004), and a far larger percentage had terminated their study of mathematics at Grade 9, 10 or 11 level as opposed to continuing to Grade 12 and then failing. In 2005, 81% of the students had abandoned their mathematics study before Grade

12 as opposed to 59% in both the previous years. There was a slightly greater proportion of male students than before, and also a slightly reduced proportion of African students, down to 71% from 79% in 2004. This cohort included 19 students were either repeating the module having failed it in 2003 or 2004, or were doing the MLE module having failed Basic Mathematics and changed their teaching phase specialisation. The lecture timetable was designed to suit first year students only and so these repeats had clashes on one or other of the lecture days. I organised a clash lecture for them where I caught up the work that they had missed on whichever day they had a clash. This had the effect of creating a small class just for the repeat students.

6.3.1 The 2005 module unfolds

The mathematics content of the module was unchanged from the previous years, but in addition to the notes, a CD containing an electronic version of the module notes annotated with links to websites with useful supplementary notes or practice examples, or references to specific sections in relevant books on reserve in the library, was provided. The intention of these links to self-study resources was to engender a sense of independence in the mathematics learning of the preservice teachers that would hopefully empower them to learn any mathematics they might need in the future. The description of the initial weeks of the module comprises edited extracts from my teaching journal from that time which will provide some insights into the day to day running of the module.

Introductory weeks

Lecture 1 Tuesday 15 February 2005

This was the introduction and I had about 50 students….Started a list of clash students (all repeats have a clash). I can see them on Monday 7 &8 which I am happy to do as they need to pass and also I am very interested in monitoring their learning second time around especially as I couldn't persuade any repeats from last year to speak to me. Generally a nice atmosphere and a promising start. Hope the group stays small.

Lecture 2 Friday 18 February 2005

Over the past days there has been a stream of confused students clutching grubby timetable books and wondering which block they must come to as Maths Literacy is down in two different blocks. Answer: both blocks. But now they are down for computer literacy in one of the slots and when they go to change they are told it is full and they can't do it this semester. I phoned the computer people to complain and insist that these students do the computer literacy this semester. Once again the late, the confused, the unsophisticated are being pushed around. Computer literate students who will write the initial test and then be exempt have secured places because they follow procedure and register at the proper time.

In this lecture we talked about the nature of maths and some maths myths. It was all quite jolly and provoked a lot of discussion. During the second half of the lecture I did the maths bills of rights. Each group was allocated a playing card name and shuffled cards were distributed to each student. There were about 60 students at this stage. I was surprised to have several Black students come to me to ask what their card was - the picture cards like Jack and Queen were obviously not familiar to them. So much taken for granted. The groups worked well and now I have the charts to analyse. I was surprised to see the right to be treated as a competent adult coming up - not seen that at the top before.

Lecture 3 Tuesday 22 February 2005

In the nick of time my printing has arrived. I give the measurement pre test and suggest the students come down and walk across the front taking the notes pile by pile. I didn't see the title page so nipped down to look for it and returned to chaos. Students were going around the back of the desk and grabbing single pages (not the whole set), realizing their error and coming back and barging in or reversing. Major snarl up and notes everywhere. Also poor manipulative skills so took so long to get down to the separating page. I was furious. Eventually got more or less sorted and started the measurement section which went OK. Read the Bill of Responsibilities too and gave a lecture on patience etc. Unfortunately the notes did run out so grabbing was shown to be a good idea. I should have had plenty because there were about 6 clash students not there. After the lecture, a student speaks about her clash and tells me she is doing 7 or 8 subjects. Impossible for weak students! Who is allowing this?

Lecture 4 Friday 25 February 2005

I was only able to be present for 30 minutes of this lecture so asked Pralisha to come and help with the tutorial examples and the administrative assistant to hand out the CDs. Very proud of those CDs - they represent a lot of work by a lot of people and the Audiovisual department did them from Monday afternoon to Wednesday which was quicker than they promised. We did a little on the place value of decimals. Money is a good example as R623,89 is clearly thought of as 6 hundred rand notes down to 9 cents and hopefully the relative size will be understood in terms of measurement. And then I rushed through a few examples on estimating. For example: 45,7 x 1,03 is about what?

Ben says about 47,1 because 45 x 1 is 45 and then 0,7 x 3 is 2,1 and then you add them up. Much confusion. I wrote down what he said on a transparency so we could understand what he was saying and said this was not correct. Then I spoke it through with the idea of multiplying by 1 as a benchmark. We still get about 47. Now other students are confused about the working I wrote down on the transparency that also gave about 47 but was wrong. Had to write on transparency that this was flawed thinking that happened to give a helpful result this time. The next example involved using multiplying by 0,63 using 0,5 as a benchmark, and on a very confused note and mutters of "this is why I can't do maths" I left for the school prize giving. Monday will tell what transpired.

Lecture 5 Tuesday 2 March 2005

Busisiwe came to see me on Tuesday morning delighted with the CD. *It is lovely and the picture of you - I can have it up on the screen. I was clicking here and there - there is so much on the CD*. Very gratifying in comparison to another student, Tom whose only comment has been to point out that the answer to the sample exam papers are not on the CD. This was the first videoed lecture. The two students employed to help me (Adam and Grant) looked over the equipment and Grant did the videoing. I did decimals and amazed at how they battle and also the anecdotal type of methods suggested. Most were convinced dividing by 0,43 would give a smaller answer (half remembered school rule). Grant remarked it is hard believe they went to school. I am very interested to see how the students sit. On my left are all the African men and on my right the African women near the front, white students in the middle and Indians at the back. Brian, a much older white student, sits right in the front on the left and seems amused by the whole goings on.

Lecture 6 Friday 5 March 2005

During the week, Samuel came to my office and left his notes behind. They are all together with a single staple at the top. The sections are upside down and back to front and a page of English notes is stuck in the middle. He was a late student and seems very disorganised. Rokum (the computer assistant) phoned to ask for a copy of the CD as he has had queries in the student LAN - I take this as a good sign as they are obviously being used. I am incensed to be told that there is no money available for tutors for this module - colleagues have organised their tutors ahead of me and the funds are exhausted. We will have to make do with myself, and Pralisha and the students paid from the SUKAR funding.

Adam meets me well before 8 to set up the video camera and seems very interested in it all. He has taken the stuff and will hopefully produce something next week. The lecture went quite well, we did a few demonstrations and we spoke about benchmarks for volume, mass and temperature and then a bit on conversions. I am pleased with the videoing progress and enjoy having Pralisha and Adam and Grant around.

Questionnaire: How are you getting on? (Week5)

The 2005 version of Instrument Six (see Appendix F) was used in the fifth week of lectures, after the first test. The results of this instrument indicated how the preservice teachers perceived their progress, the extent to which they were making use of the independent study resources, and their perceptions of the class environment and lecture delivery.

Figure 6.2 illustrates the responses to the first question where the preservice teachers were asked to choose the sentence that best described how they felt they were getting on.

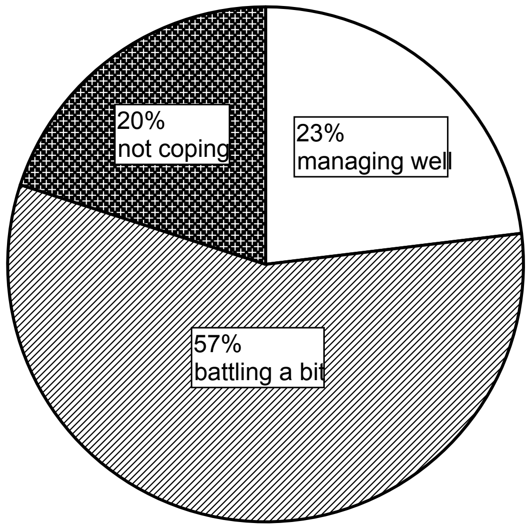


Figure 6.2 Descriptions of how preservice teachers felt they were getting on with the MLE module

The very few comments written after this question were mainly identifying a particular section of the work that caused difficulty, such as *decimals are giving me a hard time, it beats all my efforts* (Alfred). Busani indicated that he *needs much time of thinking* and perhaps the most perceptive comment came from Elizabeth who observed that *the test will show if I should have put a cross in block 3* (not coping).

The second question asked the preservice teachers to indicate which resources they had used to prepare for the test. Only 68% indicated that they had used the lecture notes which I consider to be the core resource, 29% had used the CD, 27% had used the voluntary tutorials, 5% had used the books in the library and 41% had used their peers as a learning resource. The majority of the students (58%) indicated that they had used just one of the resources and only three students had used four resources. Everybody indicated at least one resource. The use of the independent resources, especially the books, was low in comparison with the more social resources of tutorials and peer groups.

Further questions relating to the use of the CD revealed that 94% of the students had used the CD at least once (but 37%, just that once to see what was there), and that 80% of the students had used the CD in the student LAN. Only 45% of the students indicated that they did not need any help in using the CD. Busani, for example, wrote *I don't know how to use computers* and Patty also remarked *I find it very difficult to use the CD*. Consequent to this questionnaire I organised for Adam (my video assistant) to accompany students needing help to the LAN and show them individually how to navigate the CD.

The remainder of the questionnaire related to various aspects of the lectures that I thought might be important. Firstly, the students were asked about the language used in the lectures. Fifty of the 66 students who responded indicated that the language was easy to understand, nine students thought it was fine if they concentrated and seven indicated that they were battling to understand the language in the lectures. Analysing the response by race reveals, not surprisingly, that all sixteen students who indicated language problems were African and most likely to be English second language speakers. Put another way, 35% of the African students do not find the English used in the lectures easy to understand. The comments reflected those who found the language easy: *She is using simple English anyone could understand* (Lungile), and *English is the language that are used in all our subjects. So it is easy to understand it* (Ntombifikile); and those who found the language difficult: *I understand the language except I disturb something by my mind* (Anonymous), and *sometimes other words I don't understand* (Busani). Nobody indicated that the pace of the lectures was too slow, and only 11% felt the pace was too fast. With the exception of one White student, all those who found the pace too fast were African students, suggesting that perhaps it is related to language difficulties.

The learning environment was rated as "generally fine" by 55% of the students, and 29% indicated that they enjoyed the class atmosphere. However 15% noted that they found it hard to learn in the lecture theatre, writing for example, "*students make too much noise around me which puts me in a bad mood most of the time* (Myra), *the time I am trying to concentrate a certain group is disturbing* (Siphiwe) and *it's not the place, it's the people who make noise and make it hard for me to concentrate since I am a slow learner in maths* (Thembakile). I had noted the irritation of some students when others talked through the lectures, and at the start of the next lecture I approached the noisy group (the row of White students) and told them that they were causing trouble for others. They agreed to keep their noise down and the situation did improve.

The last item on the questionnaire asked the students to identify obstacles such as time to study, or pressure from other modules that were influencing their learning in this module. Seventeen students identified barriers in response to this question. Five of these related to pressure form other subjects, for example *I wish that other subjects did not give me such pressure, they use up too much of my time* (Gladness). Two female students, Jackie and Frances, wrote that they do not have much time to practise due to *house work and baby work* and having *an 8 month old baby to look after*. Other barriers included *my negativity towards maths* (Rashena); the *discipline from a certain group is a bad influence* (Siphiwe); and the difficulty resulting from poor language comprehension (Quebekani) and difficulty with the subject content - *there is too much work which needs attention and hard working* (Valencia).

In summary, while the majority of the students seemed to be coping, some students were battling with accessing the resources, understanding the language of the lectures and being distracted in the large venue. Where possible, measures were taken to provide relief from these difficulties.

Reflections on the data handling test (Week 10)

The 2005 version of Instrument 6 as described in Chapter Four, (see Appendix H), was a structured questionnaire aimed at finding out how much independent work was being done by the preservice teachers, their study behaviours, and the use that they were making of the resources supplied to them. The initial section of the questionnaire was concerned with the test preparation. The first sub-question asked for the length of time spent studying for the data handling test. The preservice teachers gave answers in hours and/or minutes and the results are displayed graphically in Figure 6.3. In this graph, the solid line within the box represents the median time spent studying for the test i.e. it shows that half the students spent less than two hours studying for that test. Approximately another quarter spent between two and three hours, and the final quarter spent between three and five hours. These three outliers, identified by their pseudonyms, indicated times spent studying that were out of line with the rest of the data.

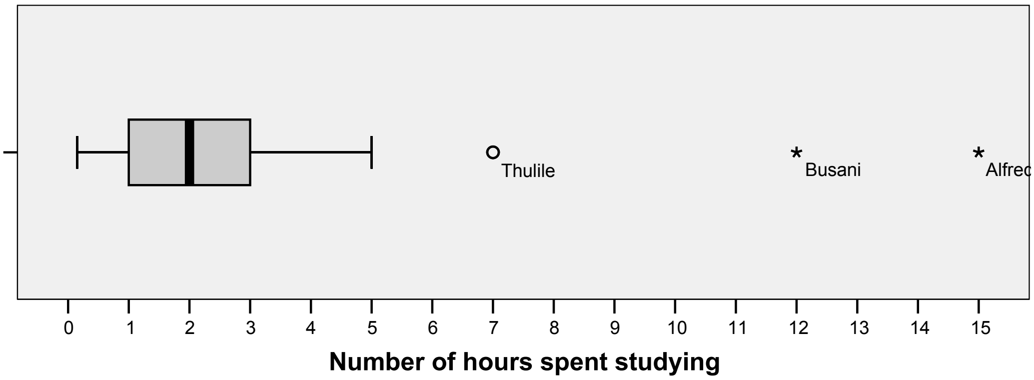


Figure 6.3 Time spent studying for data handling test

It is very interesting to consider the relationship between the self-reported time spent studying, and the marks obtained in the data handling test. Although the Pearson correlation coefficient is 0.265, indicating only a weak positive correlation which was not statistically significant at the 5% level, the scatterplot representation in Figure 6.4 is instructive.

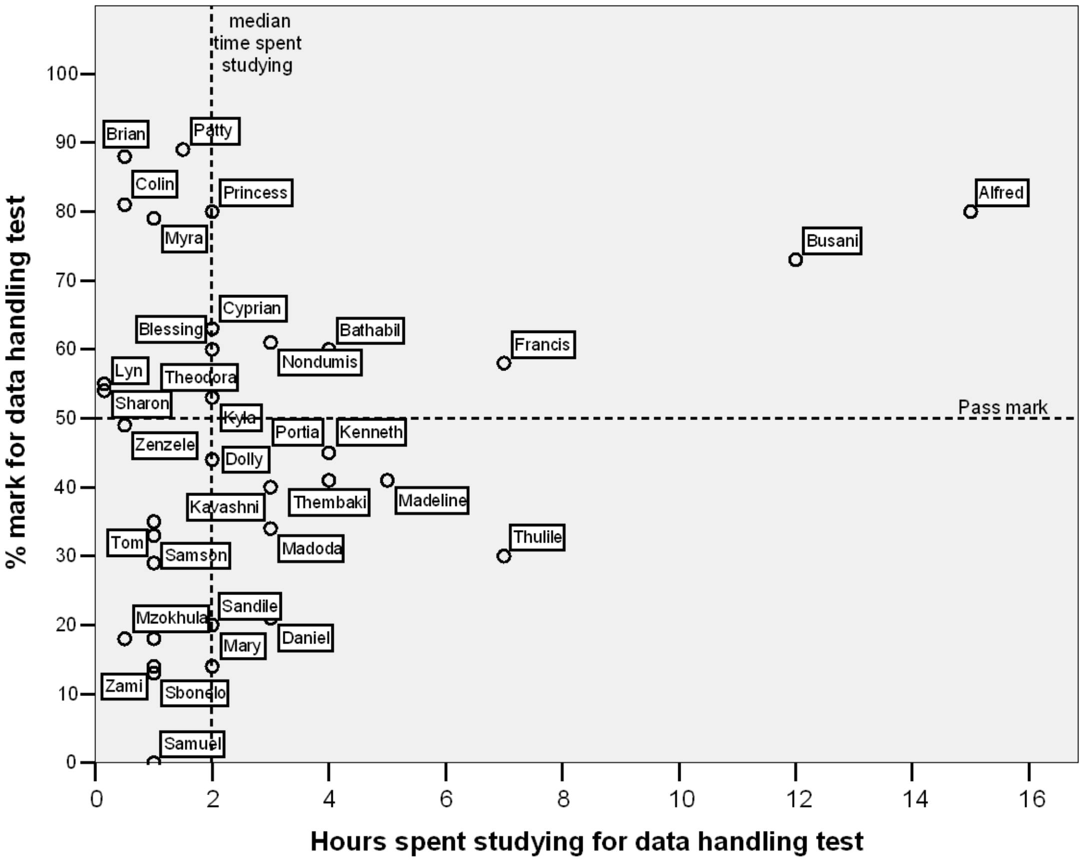


Figure 6.4 Relationship between time spent studying and marks obtained in the data handling test.

Alfred and Busani were well rewarded for their time spent studying, obtaining marks in the seventies, but Thulile performed very poorly (refer back to Figure 6.3 where these three students present as outliers). The bottom left hand corner of the graph is populated by students who reported spending less than the median two hours studying and obtained failing marks, while there is also a cluster of students in the upper left hand corner who got high marks despite reporting studying for less than two hours for the test. The lack of strong correlation between time spent studying and marks achieved could possibly be attributed to the different levels of mathematical preparation that students brought to the module.

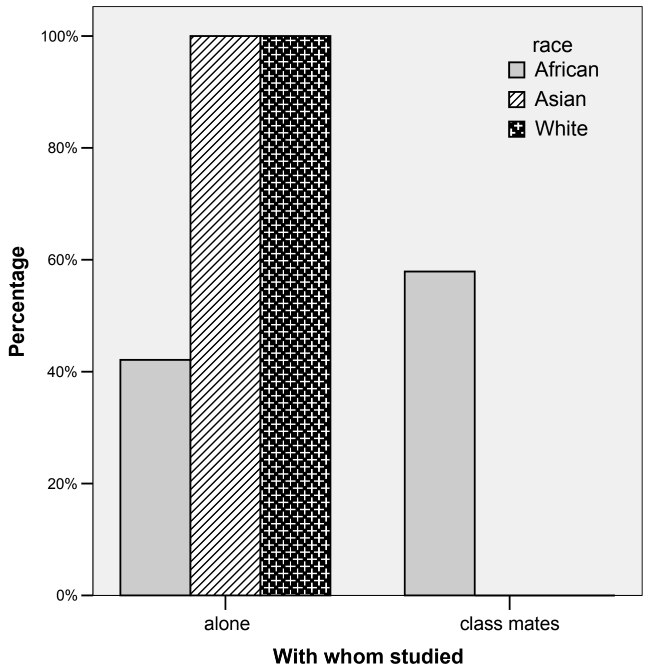


Figure 6.5 Percentages of preservice teachers who studied alone or with classmates, disaggregated according to race.

The next sub-question asked where the preservice teachers did their studying, and with whom. Overall, 54% of the students who answered the questionnaire reported that they studied alone, and 46% with their classmates. When the data is disaggregated according to race, the percentages reverse and 42% of African students report studying alone as compared to the 58% who studied with their classmates (see Figure 6.5). No White or Asian student reported studying in a group, and no data was available on the Coloured students as none of them answered this questionnaire. Disaggregating the data according to gender revealed that the 60% of the male students studied alone, compared to just 48% of the female students.

Figure 6.6 shows the proportion of preservice teachers indicating that they used each of the various study venues. The fifteen percent who studied in the LAN were presumably using the CD as a study aid.

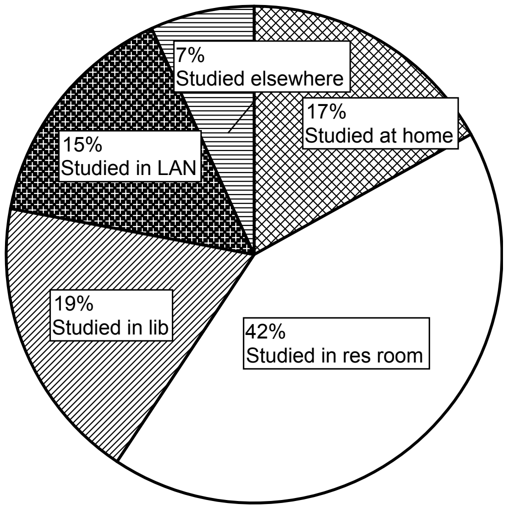


Figure 6.6 Study venues reported by preservice teachers in 2005 MLE cohort

When asked what resources they used to study, students suggested notes, yellow pages (the workbook section of the notes), the CD, the books in the library and other students. The number of students mentioning each resource is shown graphically in Figure 6.7. The maximum number of students is shown as 50 since only that number of students answered the questionnaire. It is surprising and almost unbelievable that the lecture notes and yellow pages were not used since they were the core resource. There is a possibility that the preservice teachers did not think to mention these but rather gave the additional resources such as the CD and books. Nevertheless, the data showed that the use of the CD was only reported by 39% of the preservice teachers answering the questionnaire, and the use of the books by 10% of those answering the questionnaire, or in absolute terms, just five students. This is slightly up on the percentages reported on the initial "How are you getting on" questionnaire.

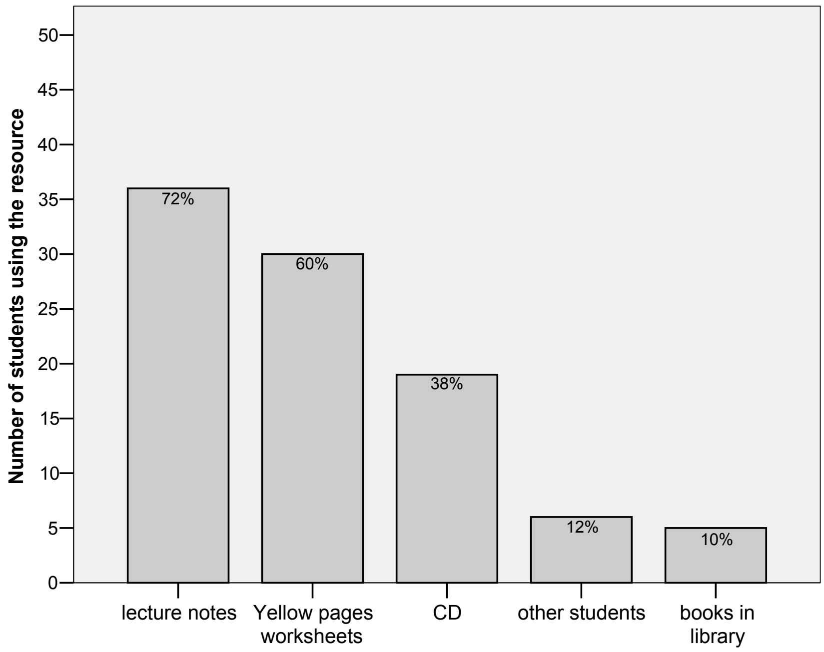


Figure 6.7 Number of preservice teachers using each learning resource

The second section of the questionnaire dealt with the preservice teachers' expectations in terms of marks for the test, and the marks they actually received. As shown in Figure 6.8, the vast majority of the students expected better marks than they actually scored, with only 2% or one single student claiming to have got the mark expected. Despite this disparity, 75% of the preservice teachers indicated that they regarded their test mark as a fair indication of their ability.

Some students admitted that they had not studied for a variety of reasons. Zenzele wrote that *I did not study much because I had loose (sic) hope because I have never passed even a single task. I thought I would not get a DP.* Others felt disappointed that they had not been able to do the work in the test, despite thinking they knew the work beforehand. They wrote: *I knew better than I got for marks* (Thembakile), and *sometimes I tell myself that I know while only to find that failing to understand a question it's a mess. Not that you don't know but you was out of the question* (Daniel). Samson was aggrieved at the marking of his test: *It's not fair, even if I write wrong methods but I draw the graph correct. You simple give me zero.*

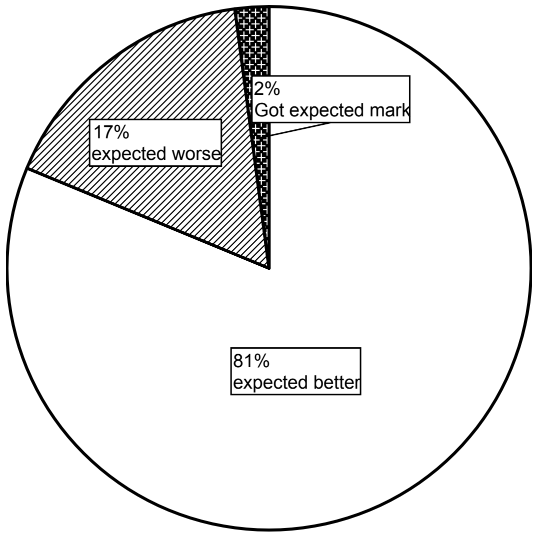


Figure 6.8 Preservice teachers' expectations of their test mark

The preservice teachers had lots of suggestions about their study plans ahead of the exams. These were typically to get together with other students and practice, use the CD and books and to put in sufficient study time. Mozibako was disappointed with his test but had plans: *I know much before I write the test, but after the test I realise that I didn't write what I know….I will spend 1 hour each and every day practising what I don't know…I will meet my friend that know better than me and organise myself.* Unfortunately he failed the examination, and also the subsequent supplementary examination and did not return to repeat the module in 2006. Two students explained quite clearly why they were planning to work hard: *so I can pass it and get it over and done with. Forget it for my whole life* (Thembakile) and Blessing planned to *study very hard to pass maths and do away with it*. Both these students got their wish - they passed and moved on.

6.3.2 Preservice teacher reflections on the 2005 module

The module evaluation was essentially the same as that used in 2004, with the addition of nine questions relating to the self help resources that were a feature of the 2005 cycle of the module. Exploratory factor analysis of these additional nine items revealed three components which could be used to reduce the nine items to three scales.

Value of the CD as a learning resource scale. (Cronbach's alpha = 0.71)

I found the CD helpful in gaining more understanding of the course content

My computer skills were sufficient for me to make sense of the CD and use it efficiently

Reading a different explanation of the work on the websites has been helpful.

Independent use of the learning resources scale. (Cronbach's alpha = 0.71)

I plan to make use of the CD and books during study week
Having resources to help me practice the mathematics on my own has been helpful
I plan to borrow the videos of the lectures to help me revise during study week.

Value of the books as learning resources. (Cronbach's alpha = 0.64)

I found the books mentioned on the CD and on reserve in the library helpful gaining more understanding of the course content
I was able to borrow the books on reserve without any trouble.

Item 44: "The lecture notes were sufficient for me, I didn't need any extra resources", loaded sufficiently onto the third component but internal consistency analysis revealed that the Cronbach's alpha was considerably higher (0.64 from 0.54) if this item was omitted. Since it was, in any case, a null response it was omitted from the scale. Item 39, related to the adequacy of computer skills, loaded onto both components, but was included only in component one (usefulness of the CD) where the loading was higher, and where it made more sense.

As with the 2004 data (see section 6.2.2), the mean cohort agreement with the composite statement for each subscale was computed. Table 6.2 shows that the mean agreement in 2005 was very close to, if not identical, to that computed for the 2004 cohort. Consequently, the interpretation of the mean for each subscale is not repeated here. Likewise, the comments made were in a very similar vein to 2004, and so only those comments related to the two new themes for 2005 i.e. the self help resources and the special clash lecture for repeating students are discussed.

As in 2004, a one way ANOVA was used to explore the relationship between the scores for each scale and the groupings of gender, race, type of school attended and school mathematics background, and three differences to the 2004 cohort emerged. Firstly, within the 2005 cohort, race was a significant grouping variable for agreement with the statement "I developed personally through this module" with the African students' mean score of 4.01 (agree) being significantly higher than the White students' mean score of 3.29 which is more neutral. Secondly, whereas in 2004, race was a significant grouping variable for the scale summarised as "I was able to cope with the language, pace and level of difficulty in the lectures" in 2005, the significant grouping variable was the type of school attended. The students who attended adequately resourced schools, agreed more strongly that they could cope than did the students who attended poorly resourced schools. In the South African context, because of the legacy of the resourcing of schooling prior to democracy in 1994 being closely tied to race, I do not consider the results in 2004 and 2005 to be contradictory in any way. Thirdly, female students accorded significantly more agreement to the statement "the class ethos took account of cultural and language differences" than did the male students. The ANOVA tables for each scale where a significant difference was found, are reproduced in Appendix V.

Table 6.2 Comparison of mean scores for each component in the module evaluation for 2004 and 2005 cohorts

	2004 cohort			2005 cohort		
	N	Mean	S.D	N	Mean	S.D
The lectures were delivered with expertise, clarity and enthusiasm	106	4.37	0.7	44	4.47	0.6
The lecturer motivated and encouraged me	102	4.29	0.6	46	4.16	0.8
The tutorials were helpful	100	4.27	0.7	-	-	-
The assessment was fair and helpful	105	4.17	0.7	46	4.05	0.6
I developed personally through this module	111	3.89	0.8	48	3.88	0.7
I developed mathematically through this module	105	3.81	0.7	42	3.75	0.9
I put sufficient effort into the module	105	3.77	0.7	45	3.60	0.9
I was able to cope with the language, pace and level of difficulty in the lectures	112	3.70	0.8	47	3.69	0.9
The class ethos took account of cultural and language differences	109	3.69	0.6	47	3.57	0.9

Figure 6.9 shows the mean agreement with each subscale of the module evaluation for the 2005 cohort. Although, as mentioned, the mean scores are very similar for both the 2004 and 2005 cohorts, this graph shows how the new subscales fit into the rank order of agreement.

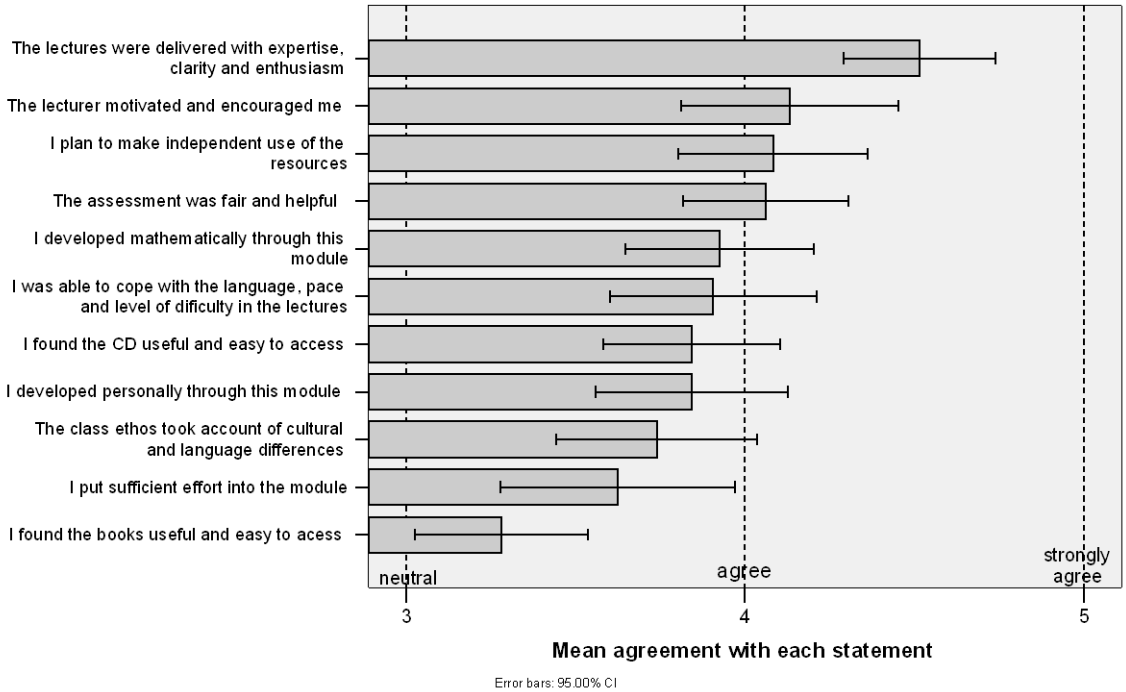


Figure 6.9 **Mean agreement with each subscale of the module evaluation for the 2005 MLE cohort**

Independent learning resources section of the module evaluation

The first sub scale related to the value of the CD as a learning resource and the three items forming this scale were summarised in the single statement: "I found the CD useful and easy to access." The mean agreement with this statement was 3.8 which is below the agree score of 4. In each of the items making up this scale, about 30% of the responses were neutral, and less than 10% negative. This could indicate that the students had not really tried to use the CD and so could neither agree nor disagree with the usefulness of this resource. This interpretation is supported by the 47% neutral response to the item stating that the books for loan were useful. From previous data it was clear that very few students had made any attempt to access the books and so they could offer no firm opinion on either their usefulness or their accessibility. The third subscale summarised as "I found the books useful and easy to access", had the lowest mean agreement of 3.3 which is closer to a neutral response than to agreement. There was stronger agreement with the subscale related to intended use of the independent resources. Two of the three items that made up this scale were, in a sense, good intentions, and the intention to use the CD and books in the study week attracted moderate to strong agreement with a mean of 4.3 making it the third highest ranked scale. ANOVA testing revealed no significant differences in the mean agreement with any of the three scales among the groupings according to gender, race, type of schools attended or school mathematics background.

There were only eleven comments related to these resources made on the module evaluation by the preservice teachers. Nine of these were positive for instance: *I really think the CDs and books were helpful and they put me to clarity* (Anonymous); Samson felt that the CD contained only a *small number of practice examples* and Samuel wrote that *it was difficult for me to study by CD in the computer since I am not good in using the computer*. In summary, the preservice teachers agreed that the CD was a useful resource and were neutral about the books, but the intention to utilise the resources for independent practice in the study week was strong.

Insights from Repeat students

As mentioned in the section on the introductory weeks, most of the repeat students had timetable clashes on either the Tuesday or the Friday, depending on their major subjects. To help them keep up with the work, I organised an extra lecture on Mondays and the students sat on one side of the lecture theatre if they missed Fridays and on the other side if they missed Tuesdays so I could keep track of who had missed what. This seemed to increase the motivation of the students. Kavashni's comments illustrate this: *From last year to now. Wow, what a big difference. I'm managing better, the individual help is great....Thank you. I know I have the ability to pass if I put in the extra effort* (How are you doing questionnaire, 2005). At the end of the module she wrote: *I seem to have put more effort in … than last year and actually want to attend classes. We had more individual attention than last year.* Kavashni passed with 57% after the previous year's failure at both the examination and the supplementary examination. Lungile also found the repeat year more enjoyable. *Mrs. Hobden was good to all of us more especially those who are repeating this module, to me it was an interesting module comparing it from last year I passed all my tests including the project accept for the last test maybe its because I didn't give myself enough time to study but in a nutshell she was very good to all of us* (module evaluation). Lungile improved her mark from 35% in 2004, to a passing 54% in 2005. In conclusion, it seems that having the repeat students in a smaller group assisted them, at least in some cases, to improve both their productive disposition and their overall mathematical proficiency as measured by the course marks. This provided a pointer towards an additional support strategy for struggling students. The subsequent implementation of a strategy of small peer group support in 2006 lies outside the scope of this study which has been presented as a case study bounded in time from the beginning of the 2003 module to the end of the 2005 module.

6.3.3 Co-worker insights

The co-workers this year were the two PGCE students, Grant and Adam, who had helped with the videoing of the lectures and done some tutoring, and Pralisha Reddy, a Masters student, who helped with tutorials and the administration of the module. They all filled in the questionnaire I provided at the end of the semester (see Appendix Q), which asked for their observations regarding the learning of the preservice teachers, and all the quotes in this section are taken from that source.

While he was setting up the video camera, Adam often chatted to the students who arrived early for the lectures and he noted that *a general lack of self confidence was expressed amongst most of the learners. The learners appeared to feel that the material, while of benefit to them, focused on skills that they hadn't used for some time, they expressed concern about not having refined their skills sufficiently for the actual activitie*s. Grant and Prelisha also commented on the lack of basic mathematical skills, even bonds and tables, with Grant, who had himself attended an elite boys boarding school writing that he *found it hard to grasp that they did not do mathematics in matric, and many of them seemed to have the same level of understanding as a young kid….language did seem to play a role. Some of the black people did not seem to be able to read, write or speak English properly. They also seemed to battle with some of the concepts.*

When asked whether they thought age, gender or race had made a difference to the learning of the students, both Adam and Prelisha observed that the older students were more focussed, and exhibited better learning behaviours such as punctuality and self motivation. There were no observations of gender differences recorded. Prelisha, though noted that *Black students seem to be disadvantaged when it came to using the CD on the computer. They also experienced difficulty with the comprehension of what was expected of them eg, written word problems or instructions due to some being English second language speaker*s. Prelisha thought that the preservice teachers learned most successfully in the small informal tutorial groups where they could ask questions. Adam had noticed that the mature students tended to sit near the front and suggested that organising small groupings of students near the front of the lecture theatre might assist their learning.

6.3.4 A way forward for 2006

My planning and looking for ways to improve the next cycle of the MLE module was interrupted by the news that curriculum changes in the Bachelor of Education programme had necessitated the shift of the MLE module from the very overcrowded first year of study, to the second year of study. This had several implications. Firstly, many of the difficulties identified as arising from unfamiliarity with university systems, lack of computer literacy and poor study habits would be lessened by the time students got to second year. This would hopefully allow them to put more energy into the module content. Secondly, this change of step meant that the module need not run in 2006, but rather again in 2007, under the new name of Mathematics for Life and Teaching, once the new cohort reached second year. I took this opportunity to run the module in 2006 for those who needed to repeat it, or for any reason had it outstanding in their credits. The story of this group of 53 students, the 2006 cohort, lies outside the scope of this study. Thirdly, this change marked a very clear end to this case study which was closed at the end of the 2005 cycle of the MLE module.

6.4 MATHEMATICAL PROFICIENCY BY THE END OF THE MLE MODULE

In the very limited way in which passing a single semester module addressing some basic and introductory mathematical literacy competences can be construed as having achieved proficiency, the following table charts the accomplishments of the 254 preservice teachers involved in the three years of the MLE module.

Table 6.3 Summary of results obtained by preservice teachers for the MLE module 2003 - 2005

Result	First attempt	Second Attempt
First class pass	11	0
Second class pass	54	3
Third class pass	83	12
Condoned pass	12	2
Supplementary then pass	11	2
Supplementary then fail	36	6
Fail examination	12	1
Fail due to no DP	32	2
Absent from examination	3	1
Total	254	29

It must be noted that over the three years there have been a total of 83 failing results on first attempt, of which only 19 have been redeemed at the second attempt. This means that there are 64 results remaining at a failing grade, and consequently standing between the preservice teacher and graduation. Some of the students are known to have abandoned their studies but what is evident is that many students are delaying repeating the module, either due to lack of inclination or due to the pressure of repeating other modules which are delaying progression. This is borne out by the registration in 2006 of 53 students to either repeat or catch up the module under a special curriculum arrangement. This included several students trying the module for the third time, and several students in their final year of study who had this one last chance to pass the MLE module in order to graduate.

A one way ANOVA was used to explore the relationship between the final module marks and the identified groupings such as race, gender, types of schools attended and school mathematical background. There were only two statistically significant results, both displayed in Appendix V. Firstly, race made a difference with the white students achieving a statistically significantly higher average mark than any other racial grouping, and secondly, the type of school attended made a difference with those who attended ex-Model C schools achieving statistically significantly higher average mark than those who attended less well resourced schools. Of course, the interpretation of this is complex and clearly linked to issues of socio-economic class, language proficiency, and politically engineered disadvantage, all of which have been discussed earlier.

6.5 PRODUCTIVE DISPOSITION BY THE END OF THE MLE MODULE

Mirroring the question posed at the end of the discussion on the initial dispositions of the preservice teachers (see section 5.5), after the stories of the three cycles of the MLE module have been told, the question now is to what extent the preservice teachers exiting the MLE module see mathematics as a useful and worthwhile subject, and see themselves as people able to learn and do mathematics successfully?

I think that it is likely that a person's success in the module would have a large influence on their attitude towards the subject. Rory, who did well, commented that he had *begun to enjoy maths (just a little) and feel confident to approach maths problems* (module evaluation, 2003) At the other extreme, Bathebile declared emphatically that she had found the MLE module *very difficult I don't want to do it again, never* (module evaluation, 2003), and somewhere in the middle was Thulile who claimed to have learnt *how to calculate and have developed interest in Maths but failed it anyway, but was worth a try usually I hate maths* (module evaluation, 2004).

In the course of the interviews, held a few weeks into the semester following the MLE module, Promise reported that her friend Gabi was using the skills she had gained in the MLE module in other subjects. *Something that I found out is that Gabi is applying those graph things in her natural science or diversities* (modules). *They are applying the knowledge from Maths literacy to the other course and she was so happy. I was surprised because Maths literacy is still here.* This is evidence that one student at least was beginning to perceive mathematics as useful and worthwhile! An unusual success story is the case of Boni who did the MLE module because she had left her school mathematics at Grade 11. She did quite well in the module passing with 55%, and together with several other successful students "illegally" registered for the foundational module for secondary school mathematics teachers even though she did not have the requisite pass at Grade 12 level. I have watched her develop into a confident young lady, and more surprising watched her continue to pass all the Mathematics for Educators modules and will watch her graduate in 2007 as a FET mathematics teacher!

Preservice teachers who battled with the module content, were less certain that it was worthwhile. *My comment is maths is not for everyone. I think it will be much better if those who like to do it, do it. Because it causes a lot of pressure if you fail like anything. Maths is not an easy subject. People should be given a choice to do it. But otherwise it is interesting for those who like it*. (Busi, module evaluation, 2003). The MLE module seemed to confirm the poor image some preservice teachers had of themselves as mathematics learners. Paul blamed himself for failing: *Ja that's the problem, I didn't study my work….I worked with some people, although I worked with some people I was lacking, I was lacking….You taught me very well as much as possible and I heard you, your language is clear, language was not a problem. I blame myself for failing this course.*

In conclusion, I think the preservice teachers who passed, left the module with a better image of themselves as mathematics learners since at last they had passed a mathematics examination. Likewise, those had done well would have gained a better appreciation of the usefulness of mathematics and its worth than those for whom it all remained a mystery. It is hard to see how a productive disposition towards mathematics can survive in the face of continued failure.

6.6 SUMMARY AND COMMENTARY

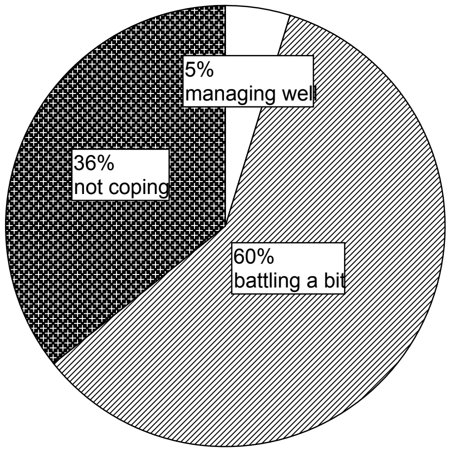
The three part story of the initial three years of the MLE module has been related with the purpose of closely detailing the learning of the preservice teachers involved so as to better understand the pedagogical practices and learning behaviours that either facilitate or disable learning. In the ensuing section I will highlight themes that I see running through all the years, and locate them in the body of literature reviewed in Chapters Two and Three.

6.6.1 Learning behaviours

Returning to the discussion of constructivism, (see section 3.1.2), and in particular the three principles for organising learning suggested by Wilson and Lowry (2000), corresponding principles for good learning behaviours can be identified. Put simply, these are (a) gain access to rich sources of new knowledge, (b) engage meaningfully with the content, and (c) discuss the new ideas with others. Continuing in this vein, in the context of the MLE module, appropriate learning behaviours were to use the lecture notes supplemented with the independent learning resource CD and books from the library to access the new information; spend time engaging with the content and trying to make personal sense of the work: and finally meeting with peers or tutors to test the new understandings. Reading the stories of the three cycles of the MLE module, it is apparent to me that very few students followed all three steps. Some failed to utilise the opportunities provided to access extra information, some failed to spend time on private sense making and went straight to sit as observers in study groups or tutorials, and some tried to make personal sense of the work and failed to test their understanding among others by attending either study groups or tutorials. There were some examples of good learning behaviours. Benisani, a very successful student exemplifies good learning behaviour in this account of his learning: *When it comes to Mathematics, I discovered that it needs practice. You get information from the lecturer and then if you just sit and relax and don't practice then you won't master whatever your are learning. I think it needs more time. It needs practice. You have to commit yourself and then you will make it. That's what we did with my friends. We would come together and talk about it and try work it out and see if it works. If it doesn't we would try another way* (interview, 2004).

Mature learning also includes realistic self-monitoring of learning, which leads to reasonable judgement of success. The questionnaire "How are you doing?" used in 2004 and 2005, called for this judgement. The distribution of responses in the two years is represented in Figure 6.10, showing that the proportion who thought they were managing well was much higher in 2005.

2004 cohort



2005 cohort

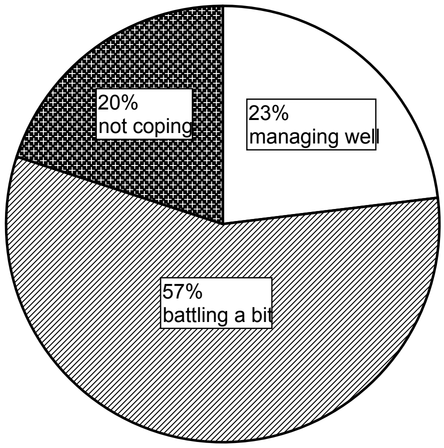


Figure 6.10 Comparison between the self judgements of progress for the 2004 and 2005 cohorts

The greater confidence in 2005 was not necessarily well founded. All the preservice teachers who indicated in 2004 that they were managing fine, subsequently passed the examination, whereas in 2005 this percentage was only 60% (9 out 15 preservice teachers). Perhaps the interactions in the tutorials in 2004, provided an arena to gauge ones own progress. Later on in the 2005 module, when preservice teachers were asked if they achieved better, worse or as expected in the data handling test, only one indicated that the expected mark was obtained. A realistic judgement of the extent to which one has mastered work is very valuable in judging the time and effort required to prepare for tests and to complete tasks. Perhaps the comments by preservice teachers that they understand in class but cannot do the work alone indicates that they fail to appreciate that it takes time and effort to make personal sense of the work. In some cases making personal sense of the work is severely hampered by a very poor foundation in basic mathematical concepts.

6.6.2 Schooling and Mathematical background issues

My experience in teaching the MLE module, indicated that many preservice teachers enter with extremely limited mathematical proficiency in all the content strands identified by Kilpatrick et al. (2001) and fully described in section 3.2.1. This makes the module a struggle, but equally crippling is the lack of a productive disposition toward mathematics. Some students seem to have started out apprehensively and in the full expectation of failure, following the trend noted by Ingleton and O'Reagan (2002) for the successes and failures of primary school, with their effect on self-identity and self-esteem to be reinforced even into the years of tertiary learning. It does not seem possible for them to "just get over it." This phenomena is well known and has been described by Tobias (1993) in terms of a "dropped stitch" (see section 3.3). Maths anxious people recall incidents and people who negatively affected their learning during their schooling, but cannot explain why, in later years, they have not returned to pick up where they left off. That said, incorrect understandings of basic number concepts seem resilient and are adhered to in the face of blatantly unreasonable answers. Figure 6.10 shows three responses to a question in the 2005 MLE examination which asked for a description of quick method to compute 5×36 mentally. A good way to do this is to employ the "double and halve" technique, practised over the semester, and work out 10×18. The responses shown indicate a lack of conceptual understanding of place value and the basic properties of operations.

Busi, whose work features in Figure 6.11, was a repeat student who had continued to employ the incorrect technique of inserting a bracket between the digits of a number despite attempts at remediation since she began her first attempt at the module in 2004 when her tutor Debbie wrote o*ne student kept on using brackets incorrectly … if the question was 56x4, she wrote 5(6+4). The student did this for every question* (Week Six tutor reflection). Referring back to Table 2.1 which provides evolving definitions of mathematical literacy, reminds us that a mathematically literate person would be expected to bring their everyday knowledge to bear on the computation and, for example, to reason that buying 5 items for R36 would surely cost more than R90 or R45, and be alerted to the unreasonableness of their answers even in this context-free computation.

5×36 $= (5 \times 3)\,6$ $= 15 \times 6$ $= 90$	5×36 $= 5 \times (3 + 6)$ $= 5 \times 9$ $= 45$	5×36 $= (5 \times 3) + (5 \times 6)$ $= 15 + 30$ $= 45$
Busi (2005 MLE examination)	Gladness (2005 MLE examination)	Gladness, second attempt (2005 MLE examination)

Figure 6.11 Suggestions of quick mental techniques to compute 5×36

The handicap of a poor basic mathematics foundation on which to build the more sophisticated competence of mathematical literacy, together with a poor disposition towards mathematics developed through negative schooling experiences renders successful mathematical literacy learning a difficult task indeed. This difficulty is compounded by language issues.

6.6.3 Language issues

A primary language competence relates to general reading skills which facilitate access to, and correct interpretation of, print based materials such as lecture notes, assignment and test instructions, and questionnaires. While reading ability was not tested in this study, there was ample evidence of misinterpretation of questions in the questionnaires used as instruments. In Instrument Two, for example, a small group which happened to comprise all African students, in response to the question "What would you identify as gaps in your mathematical knowledge and skills"? wrote *You can also identify gap as a space between words or something…also Geometry especial in line segmen*t. (Group 3, 2004). It was noticeable that some of the African students were very slow readers, sometimes seeming to be reading word by word which is a big disadvantage in timed tests. This seems to support the findings of Bohlman and Pretorius that "poor reading ability…seems to function as a barrier to effective mathematical performance" (2002, p. 201).

The tutors noted in 2003 that preservice teachers were recreating the code switching environment familiar to them from the bilingual classrooms of their school days as described in literature (see section 3.3.1) and by the preservice teachers themselves. *They feel difficulties because the way they are taught in school…they are taught English in Zulu, other subjects in Zulu you know* (Sele, interview, 2004) and *as a person from a rural area, Maths was not difficult to me (*at school*) because it was taught in first language and then sometimes explained into Zulu language* (Sipho, interview, 2003). A tutor remarked on the fact that one of the African students would listen to what he said, and then repeat it in isiZulu for the benefit of his friends. The informal study groups formed by African students and described by MLE students Alfred, Patty and Olwethu in the interviews also provided a venue for discussing the work in their home language. As mentioned in section 3.3.1, such discussions are thought by Setati (2005) to improve fluency in the discourses of mathematics with positive effects on achievement.

The use of English as the medium of instruction in the lectures has been extensively discussed in the lectures section of the module evaluations, and was a strong theme in the reflections of the tutors in all three years. Most of the lectures were delivered by myself, a native English speaker with an accent and turn of phrase that could take isiZulu speakers a while to grow accustomed to. For example, when asked in an interview if he could understand the language in the lectures, Amos replied in the affirmative, and then paused and continued *but not as from the word go. I started understanding at the end of the* *semester* (2003). Specifically asking about the language in the lectures in 2005, revealed that 35% of the African learners did not find the English used in the lectures easy to understand (see section 6.3.1). The language difficulty could well explain why preservice teachers felt that the pace of the lectures was too fast for them.

When conducting the interviews in 2004, I had a different set of questions for the students who had achieved distinctions and it was immediately striking that the African students who had done well all spoke excellent English. Whether it was their language proficiency or their schooling in English medium schools is open to debate. Doing well in the MLE module is certainly not an automatic consequence of schooling in English since Zami, who went to an elite private school and by her own admission *had every resources I need for my studies* (mathematics autobiography, 2004), finally passed the MLE module in 2006 after repeating it twice, and there were many failures among students whose home language was English. It would be as equally unfounded to assume that good language skills imply good mathematical skills, as it is to ascribe all the difficulties experienced by African students to language difficulties.

6.6.4 Issues of diversity and cultural responsiveness

As highlighted in Chapter One, a primary motivation for this study was to document very carefully the stories of the preservice teachers entering the MLE module, and the stories of the unfolding of the module in 2003, 2004 and 2005, with the intention of strengthening my position of advocacy for students disadvantaged by their schooling background. The diversity issue does not relate only to race and gender, but also to the discrimination felt by those who do not succeed in the high status subject of mathematics. I concur with Benn (1997) that all too often "equity can be seen as pretending not to notice, as removing consideration of gender, class or race on the grounds of equal opportunities. However, if we remove these definitions from our discourse, then we cannot challenge prejudice when it occurs" (p. 137).

As evidenced in Table 2.5, the female students were slightly in the majority in each of the cohorts of the MLE module. Commonalities between the male and female students predominated, but there were some interesting statistical results showing gender differences, as well as anecdotal observations. The only statistical difference found in the pre-module questionnaire was in the attribution of mathematics ability. The literature discussed in section 3.4.4 (see for example Leder, 1992; Meyer & Koehler, 1990; Tobias, 1993) indicates that boys tend to ascribe their success to ability whereas girls tend to ascribe their success to effort or outside help. This gendered pattern of attribution was also found in this study where the male students ascribed more influence to the Self factor (a composite of items pertaining to how clever they were born, ability to think logically and the parent's mathematics ability) than did the female students. Two gender differences were found in the data collected in the course of the 2005 module. The first difference was found in the Data Test Reflection data (see section 6.3.1). When asked if they studied alone or with others, 60% of the male students reported studying alone, compared to just 48% of the female students. This seems to conform to the preference noted by Boaler et al. (2003) and discussed in section 3.4.4 for girls to prefer a more social and collaborative style of learning. In the 2005 module evaluation, gender was found to be a significant grouping variable for the "Culturally responsive class ethos" scale (see section 6.3.2). The female students agreed more strongly that the class ethos had taken account of cultural and language differences.

From personal observation, it was apparent that the female students were more constrained by family responsibilities especially childcare and housework. For example, as discussed in section 6.3.1, when asked to identify barriers to their learning two female students mentioned housework and baby work, and a mature student from 2003 explained how she had to see to four children and sort out the house when she returned from the university (see section 6.1.2). These female students fit the profile of adult learners as described in section 2.4.3 more closely than their male counterparts of the same age who often stayed in the residences apart from their families.

I was seldom aware of racial tension in the lectures - the only instance being when I sensed that many of the African students were becoming increasingly irritated by the constant chatter of a particular group of White students. There were, however, differences in learning styles as alluded to in section 6.3.1, the reflections on the data handling test. It seems that only the African students were drawn to study in peer groups and perhaps this more social style of learning has cultural roots, as suggested by Stiff (1990) and Moody (2003) following their work with African American learners (see section 3.3.3). It must be remembered though that the majority of African students were in the residence and so the social methods of study were easier for them than for students who travel home and must perforce work alone.

The final chapter of this dissertation concludes the report of the research by presenting the insights gained from the careful and detailed case study of the preservice teachers who entered the MLE from 2003 to 2005, and the three part case study of the evolving MLE module, in the form of recommendations for practice in three areas: future cycles of the MLE module, similar tertiary level foundational mathematics modules, and mathematics teaching at school level.

CHAPTER 7

IMPLICATIONS AND RECOMMENDATIONS FOR PRACTICE

At the outset of this concluding chapter, I will briefly summarise the findings of this research study. The first research question concerned the initial productive dispositions of the preservice teachers i.e. the extent to which they viewed mathematics as a useful and worthwhile subject, and themselves as people able to learn and do mathematics successfully. The evidence presented in section 5.1 indicated that the preservice teachers entering the MLE module viewed mathematics as difficult, frustrating and challenging but useful for gaining entry to further career and study opportunities. Those who continued with mathematics to Grade 12 did so mainly due to a sense of obligation rather than any love of the subject, while those who had elected not to continue did so due a sense of dispiritment. The stories told in the mathematics autobiographies and interviews can be characterised as stories of disenchantment, where typically initially good feeling towards mathematics are soured by subsequent experiences at school (see section 5.4). In general, the disposition towards mathematics was found to be negative and hence the productive disposition strand of mathematical proficiency was considered poorly developed.

There was overall agreement from the preservice teachers that they had been helped, motivated and encouraged by the lecturer, the tutors and the assessment practices, and that they had developed personally through this module (see Table 6.2). This signals a more positive attitude towards mathematics. Understandably, the productive dispositions of those who did well in the MLE module were improved due to the confidence gained by succeeding in a mathematic module whereas those who failed were likely to have had their negative dispositions hardened.

Different pedagogical practices were employed in the three years of the module and these were fully discussed in the three part story-telling case study of the MLE module. The practice of working with students in small groups was found to be successful with strong agreement that the tutorials had been helpful in 2004 (see Table 6.2), and positive comments from the repeat students who were given separate small group help in 2005. Other helpful pedagogical practices identified in this research are reflected in the recommendations for practice that follow.

What are the contributions of this research? I think that the detailed report on the case of the preservice teachers entering the MLE module, where the voices of the students themselves tell the stories of their school mathematics experience, will speak to different readers in different ways. In contrast to many smaller and narrower research studies, this study was a truly multicultural study including all race groups, involved 254 preservice teachers and spanned three years.

The extracts from mathematics autobiographies provide rich food for thought for those involved in school level mathematics who can ponder the role their colleagues have played in demoralising learners, the sticking points identified such as the introduction of algebraic notation, and the disruptive influences of school and teacher changes. Perhaps the extent of disadvantage experienced by many South African learners will be better understood, and the issue of redress as a social justice imperative be better appreciated. The stories told are likewise instructive material for preservice mathematics teachers, presumably mathematically successful at school, who might do well to read the stories and become more sensitive to the struggles of others. Similarly, the rich description of the case of the MLE module told in a three part story, will enable readers to identify similarities with their own contexts and find insights into their own practice. Many of the lessons learned and insights gained from teaching the MLE module, are relevant to the expanding number of mathematics courses required as part of traditionally regarded unmathematical humanities programmes such as Law. The disadvantage of being schooled in a system in which the scars of apartheid are still visible, cannot, in post-democracy South Africa, be allowed to prevent people from fulfilling their ambitions. This is less likely to happen if the lessons from this research, shown to be helpful in enabling students to improve both their dispositions towards mathematics, and their mathematical proficiency, are noted. Those who teach mathematical literacy in the FET phase will encounter many of the problems of poor arithmetic background and language difficulties dealt with in the MLE module.

I continue this chapter with recommendations for pedagogical practices in the MLE module which was the focus of this study and in foundational mathematics modules in other humanities faculties. The implications of this study for inservice and preservice mathematics teachers and mathematical literacy teachers in schools are then discussed. The events of each cycle of the module, the extensive data from module reflections and final reflections, data from interviews and co-worker insights have provided rich evidence to motivate and support the pedagogical practices suggested in the following sections.

7.1 SUGGESTED PEDAGOGICAL PRACTICES FOR THE MLE MODULE

These five suggestions arise out of the extensive data collection and analysis presented in this thesis and my experience as teacher researcher in the MLE module. They consist mainly of calls to openly and honestly acknowledge the difficulties the preservice teachers might have, and to employ explicit strategies to enable the preservice teachers to overcome their difficulties.

7.1.1 Acknowledge affective baggage

It is suggested that it is useful to speak upfront about the preservice teachers' feelings towards mathematics rather than pretending that they liked the subject. It was seen that organising random groups to work on a Mathematics Bill of Rights (see section 4.6.3) allowed the students themselves to realise that their dislike and fear of mathematics was very common within this particular group of students. *So when we were in Maths literacy I saw there were lots of white people and I thought that if they had the same problem then why not me, and so we came to realise that Maths is actually everyone's problem* (Gabi, 2003). Allowing preservice teachers the opportunity to decide on their rights as mathematics learners, and to write about their mathematics experiences in their autobiographies was a means to providing them with useful self-knowledge, and the lecturer with useful insights into their hopes and fears (see sections 3.3.1 and 3.3.2).

Consideration of the mathematical autobiographies presented sensitises us as to which instructional and classroom practices to avoid. For example, many preservice teachers recall vividly being publicly shamed for their poor mathematics performance and they are extremely sensitive about their marks. For this reason,it is recommended that a point is made of keeping their marks confidential, to the extent of writing the total mark on an inside page of their test papers so when they are handed back the mark is not displayed for all to see. This gives the student the choice of disclosing their mark to their peers or not, and shows respect for their privacy.

Data from the interviews and co-worker reports indicated that students who have been mathematically unsuccessful are often very nervous about tests and examinations. Helpful pedagogical practices in this regard include talking about tests as "opportunities to show what you know" and scheduling plenty of time for tests so that nearly all of the students have time to finish and leave feeling that they have been given the opportunity to write what they know.

I have come to realise through this research that the most helpful strategy to help students overcome the affective baggage they bring to the MLE module is to be kind and to be fair. This does not in any way mean that standards are compromised or deadlines ignored - it simply entails being sensitive to their mathematics anxiety and treating students consistently and with respect.

7.1.2 Acknowledge the lack of good learning behaviours

The preservice teachers in the MLE module came from a range of schooling backgrounds (see Figure 2.4) and so arrived with differing levels of study skills and learning behaviours (see section 6.6.1). Although I forewarned the tutors in 2004 that many students were not familiar with keeping a good filing system for notes, and had even asked them to show students how to punch the notes centrally, they were still taken aback at the state of the files a few weeks into the module. *I was shocked to see how many students did not posses a file. I was also amazed at the state of many students' files. No order, notes not punched, torn notes and blank spaces was very common* (Kirsty, Week Four tutor reflections, 2004). Although checking files at tertiary level seems strange, I think it is more helpful to openly assist students with such study skills than to ignore the problem.

The tutors who had been my eyes and ears among the 2004 cohort of preservice teachers, reported that very little effort was being made to work independently in between the formal lecture times (see Section 6.2.3) and evidence from "how are you doing questionnaires" showed poor self-judgement of progress of effort required (see section 6.6.1). Rather than general exhortations to work harder, explicit explanations of good learning behaviours such as noting ideas, queries, and important learning alongside the notes should be given. Careful checklists of learning outcomes for each section also help students to monitor their own learning and develop more realistic estimations of how much they know and how much effort is required to succeed. When the assessment is clearly and explicitly matched to the checklist of outcomes, the preservice teachers are likely to feel more in control of their work.

Preservice teachers who arrive from good schooling backgrounds often know how to learn, and have many strategies for organising their own learning. It is an issue of redress to equip those from disadvantaged schooling backgrounds with some of these same skills.

7.1.3 Acknowledge diversity

Reading the stories of the three cycles of the module, and referring to Table 2.5 it is very clear that the participants in the MLE module differed widely in their ages, home language, culture, mathematical ability and schooling background. Acknowledgement of a diverse group of students implies acceptance that a "one size fits all" approach is unlikely to succeed.

Firstly, the issue of diversity in mathematical ability, as evidenced in the ability to cope with the work of the MLE module, is discussed. This diversity was noted by one of the 2004 tutors Matthew, who noted that *the students seemed to be unable to fully grasp exactly what was required of them, so I had to explain the whole purpose of the assessment to them again. This proved tedious, as some class members always seem to know what's going on, whilst others don't.* Differing levels of mathematical schooling must be considered - clearly a student who attempted Grade 12 mathematics and failed on the day, is quite different to a person who gave up mathematics in Grade 9 having never really grasped the primary school work. That said, the achievement in the MLE module as measured by the final module mark, was not statistically significantly different among the groupings according to school mathematics background (see section 6.4). The quote from Wlodkowski (1999), a colloquial version of Vygotsky's Zone of Proximal development, first mentioned in section 3.5.1 is worth repeating here: "(we) know from years of hard-earned experience that you cannot take anyone from anywhere unless you start somewhere near where they are" (p. 39). Since each student is likely to starting in a slightly different place, flexibility must be built into the programme. The independent learning resources CD and books introduced in 2005, were an attempt to empower the preservice teachers to fill their individual gaps in basic mathematical knowledge. The use of such independent resources is an area for future research.

Secondly, there were issues of diversity in gender. The gender issue did not feature strongly in the autobiographies. It was however noticeable that the informal friendship grouping in the lectures were very gendered especially amongst the African students where all the male students sat on one side of the lecture room, and the females on the other. Gender differences noted in this research were in the greater preference shown by female students for studying in groups, and the tendency for female students to attribute their success in mathematics less to their own ability that their own effort. Acknowledgement of diversity in this case, would imply allowing some freedom for students to choose their own study styles.

Thirdly, the diversity in race was evident in the results of this study where learning socially was shown to be a well used method of study for many African students whereas the members of other racial groups generally indicated that they studied alone (see section 6.3.1). As discussed in section 6.6.1, both styles play a part in "constructivist learning" and if this is made explicit, all students can be affirmed in their learning style and encouraged to include other styles as well. Flexible learning opportunities such as tutorial groups allow students to take responsibility for their own learning. This of course links back to the discussion of good learning behaviours in section 7.1.2.

The next two aspects of diversity were language and age, and these are dealt with separately in the following two sections.

7.1.4 Acknowledge language problems

This research study showed a wide diversity in language proficiency. While the vast majority of the preservice teachers in the module had isiZulu as a home language, there were several students from other African countries such as Lesotho, and several students who had done all their schooling in Afrikaans. Increasingly as the post apartheid schooling systems opens up, there are many students whose home language is isiZulu but who are very fluent in English having attended English medium schools for many years. There are however learners, especially from rural areas who are still acquiring English, and we are encouraged to "create a view of students acquiring English as learners of mathematics that combines what is known about how people learn mathematics with how they learn a second language" (Secada, 1996, p. 437). His suggestions include specifically asking bilingual learners to contribute, encouraging them to use their native tongue and asking others to translate, slowing down the fast tempo of the classroom and creating an atmosphere in which language variation in the community of discourse is an accepted fact of life. Student understanding of tasks is enhanced by "rewriting and simplifying language, using familiar contexts, and providing concrete referents" (p. 441).

The rubrics used for assessment need to be carefully scrutinised to ensure that the evidence of actual mathematical knowledge is not confounded with difficulties students might have in expressing themselves in English. Providing access to recordings of the lectures provided opportunities for students to replay the lectures and have a second chance to understand the language. While seemingly a good idea, this needs further investigation, since as noted in section 6.3.2 the students in the 2005 MLE cohort had good intentions of reviewing the lectures in this way during study week, but in the event very few did.

Acknowledging the difficulties students have with the language of mathematics and statistics points to good instructional practices such as writing the key words carefully on the board as they are introduced, and drawing attention to the different meanings that words may have in Ordinary English and Mathematical English. For example, a drawing of a cat with whiskers and pointing out the similarity in shape to a box and whisker plot might make the naming of that graph seem a little less arbitrary and confusing.

7.1.5 Acknowledge the adult education nature of the module

The wide range of ages in the MLE module, where some of the students were straight out of school and about 18 years old, and others were in their forties made diversity in age feature of this study. More importantly, it placed the MLE module in the domain of adult education (see section 2.4.3) which needs to be acknowledged. Whereas at school level, especially in the higher socio-economic classes, school learners typically have all their daily needs catered for by parents or other caregivers, and their primary work is schoolwork, this is not always the case at tertiary level. Some of the students are married and have families to care for, some are single mothers, and as AIDS takes its toll, some are becoming the heads of their households with responsibility for younger siblings. University studies have to fit in with other commitments which is not easy. Heavily pregnant with her fourth child and looking towards the following year of study Jackie said *there will be a new baby, there will be the maths and there will be everything!* (Interview, 2003). While not suggesting that the work be reduced or made easier, I am suggesting that teachers at his level do not assume that students can give their subject undivided time nor set unrealistic goals.

As argued previously, (see section 2.4.3), the act of returning to mathematics and learning foundational mathematics whilst studying other subjects at university level, makes the "adults learning mathematics" style of teaching appropriate to this module. The increasing body of research literature on this topic is often overlooked as a resource for foundational tertiary mathematics modules and it is recommended that this literature is consulted.

7.2 RECOMMENDATIONS FOR FOUNDATIONAL MATHEMATICS MODULES IN OTHER HUMANITES FACULTIES

The aims of such modules should be to facilitate the development of students' mathematical literacy in general terms for their roles as self managing persons and responsible citizens, and in specific terms for the particular professional roles they are working towards. This requires careful curriculum development with collaboration between mathematics education specialists and representatives from the professions. Arising out of my work, the MLE module will be relaunched as Mathematics for Life and Teaching in 2007, and I am recommending the design of similar modules such as Mathematics for Life and Nursing, or Mathematics for Life and the Practice of Law and so on.

All the affective factors highlighted in this study are likely to apply in these modules and so all the implications for practice in the MLE module are relevant here too. In addition, the following specific recommendations arise out the insights gained in the course of this study.

7.2.1 Use mathematics education specialists as teachers

The cognitive demand of the mathematics in such foundational modules is low, assuming no more than Grade 9 level competence in the MLE module, and only Grade 7 level competence in the module used by the law faculty. Nevertheless, some students really battle to get to grips with the work. I hope that through this study I have shown some of the many barriers to learning that have hampered and stalled mathematics learning at school level, and how the erosion of confidence has resulted in students with extremely poorly developed productive dispositions towards mathematics.

Facilitating learning in such modules requires more than the supervised practice of context free arithmetic type computations which, in my experience, is often what these modules comprise. It behoves those who have charge of such modules to seek out teachers who will develop empathetic relationships with the students and assist them to learn the mathematics they need for their personal and professional lives. I am very aware that these mathematics modules, incongruously situated in the humanities faculty, probably lie outside the area of interest and expertise of members of that faculty and so the teaching is usually contracted out. From the discussion of the recommended pedagogical practices, and with some idea of the mathematical histories of the students, it is I think clear that such teaching is a specialised task and requires more than knowledge of the mathematics involved. Issues of social justice and redress demand that students who have landed in a position of deficit mathematically, often through dysfunctional schooling are given committed specialist mathematics teachers and a module carefully designed to cater for their needs as adults returning to mathematics, and preparing for their future professions.

7.2.2 Utilise strategies specifically designed for adult mathematics education

The "returning to mathematics" nature of such modules makes the insights from the adult mathematics education domain more valuable than school instructional strategies (see section 2.4.3). Just as I found Wedege's observation that "many adults who start on vocational education are surprised that the programme includes teaching in mathematics" (2002, p. 72), relevant to the MLE module, so too I am sure it is relevant to those embarking on careers as lawyers or social workers in the humanities faculties.

The extensive discussion in section 3.4.5 on enhancing adult motivation to learn, based on the work of Wlodkowski (1999), gives an idea of the demands made on a teacher who wishes to engage in the task of encouraging students faced with a mathematics requirement on their path to their chosen profession. While children at school might be enculturated into accepting that what they are taught as "good for them," the literature on adult education indicates that motivated study with clear relevance is better received by adults than unmotivated practice at skills they cannot imagine using. The links between the learning to compute percentages and the practice of law, (for example), are not obvious, and the disposition of the students towards mathematical literacy would be enhanced if this was made explicit by the use of relevant contexts.

It is very important that students who find themselves in the position of learning as adults what might be considered elementary arithmetic, be treated with respect. Care must be taken not to confuse either the cognitive level of the mathematics being taught with the general cognitive ability of the student, nor with the cognitive demand of teaching.

7.3 IMPLICATIONS FOR MATHEMATICS TEACHING

There is little need to caution against blatant abuse of learners and unprofessional conduct such as drunkenness and dereliction of duty. All reasonable and concerned people know this to be unacceptable behaviour and we all hope that more systems are now in place to bring the perpetrators of such conduct to book. More subtle though, are the teacher actions that have no overt malicious intent but nevertheless have long lasting effects on the mathematical lives of the learners. I think many teachers would be horrified to know that their remark or action, perhaps arising out of sheer frustration, is identified maybe twenty years later as the moment of disenchantment with mathematics for a learner. Mathematics teachers would do well to remember this and to be sensitive to the fragile egos of learners who struggle and repeatedly fail. The parenting adage "Criticise the action, not the child" is good advice in this situation. Failure to understand can never be considered a disciplinary problem requiring punishment. The high status accorded to mathematics in many cultures makes failure to succeed in this subject a particularly sensitive issue. Perhaps the most salutary lesson for preservice and inservice mathematics teachers arising from this study comes the reasons given for choosing to continue with mathematics to Grade 12 level, or to terminate the study of mathematics at Grade 9 level. The leading reason for discontinuing mathematics was a composite set of dispiriting factors that included disliking the subject and performing poorly in it, and disliking the teachers. There is little to encourage us in the reasons for continuing mathematics because the main motivation there is a sense of obligation - to please parents and as a means to a good job. The composite reason of affinity, liking the subject and liking the teacher scored poorly. The implication of this is that teachers at all levels need to guard against disparaging comments which, as this research has shown, may have lasting effects.

Changes of teacher, class groupings are sometimes unavoidable for schools, as are the family circumstances that lead to children and teenagers changing schools. Great care has to taken to ease the disruption of such changes and to ensure that the learners are not left with gaps in their mathematics learning that could have lasting effect. Apart from circumstances such as mentioned above, which can cause mathematics learning to stall, some school grades and mathematics content areas were identified in this study to trigger disenchantment.

While few grades escaped mention as a time of disenchantment, it is clear that learners are particularly vulnerable in the early years of secondary school, and to a lesser extent once they have elected mathematics as a subject and they begin Grade 10. These are the places for the most experienced and empathetic teachers. It is also noticeable that the early experiences of mathematics are pleasant and get less so as schooling progresses. I am not sure that this is true in other subjects where enthusiasm and interest seem more easily sustained. Strongly related to the previous point, is the mathematics content that was identified in this study as leading to the disenchantment. For example, the introduction of algebraic symbols seems to cause trouble. This is work covered at Grade 8 level, and for this reason, the recommendation arising out of this study is that the best teachers should be placed at Grade 8 level, and particular care taken to develop conceptual understanding at that level.

The location of a new mathematical literacy subject within the South African schooling system has been described in Section 2.2.1. Learners who do not elect to continue with the study of formal mathematics past the GET phase will perforce study mathematical literacy. Many of the preservice teachers enrolled in the MLE module chose not to continue with mathematics and they foreshadow the mathematical literacy cohorts expected from 2006 on, and so the insights gained from this study can be applied to the mathematical literacy learners at school level.

The evidence (see section 5.1.3) is that learners choose not to continue with mathematics because they were dispirited and disenchanted with the subject. This is not a good starting point for engaging with mathematical literacy in Grade 10, and empathetic teachers are required to rebuild confidence. I think it is self-evident that learners who master the mathematics of the GET phase successfully will be channelled into the formal mathematics stream, leaving those less successful to do mathematical literacy. Referring back to section 2.1.2, it is clear that mathematical literacy is intended to be a sophisticated competence, developing critical thinking using the tools of mathematics. When the basic arithmetic tools are absent, the danger is that the critical thinking aspect of the subject will give way to drill and practice in basic arithmetic, and the more important personal empowerment and political aims of the mathematical literacy subject will not be achieved. It has been contended that inadequate basic numeracy is likely to be an obstacle to achieving the educational and political aims of mathematical literacy (S. Hobden, 2005).

In a previous paper (see S. D. Hobden, 2006), I have argued that being forewarned is to be forearmed, and that teachers of mathematical literacy must be aware of the likely mathematical competence of the learners they will encounter in Grade 10, and have strategies for remediation ready. In addition, perhaps those overseeing education could more productively turn their attention away from the highly publicised final matriculation marks of learners, and focus more on mathematics education in the GET phase where it all starts to go right or wrong.

7.4 CONCLUDING REMARKS

I have tried to be true to my intention to promote social justice by spending the years of this research study following the advice of Griffiths (1998) to do what I could, keep my wits about me, and my ears open and remain able to live with myself (see section 1.8). I hope that I have fulfilled the social responsibility for researchers suggested by Labov (cited in Cameron, Frazer, Harvey, Rampton, & Richardson, 1994) to apply the principles of error correction and debt incurred, by drawing the attention of the mathematics education community to the problems and issues inherent in preservice teachers learning mathematical literacy, and working towards to a better mathematics experience for those students who participated in my research study.

It has been very fulfilling on both a personal and professional level to be so deeply involved with a particular module and a changing group of students over the three years discussed in this dissertation, and beyond to 2006 and to 2007 ahead. Combining interests in research, teaching and social justice has brought together much that is personally meaningful to me. The recognition of the research will be a professional achievement, and I look forward to taking this academic work further to develop other similar foundational modules. On a personal level, I value deeply the cheerful greetings on the corridor, and the visits to my office to say *thank you being nice to us,* or just to say how pleased they are to have passed, or even to apologise for letting me down by failing. I look forward to seeing some of the 2003 cohort graduate in 2007, knowing that I have done my best to be a kind human face in a tertiary environment often perceived as hostile to naïve newcomers, and that I have in a very small way provided redress for an education system that had not served them well.

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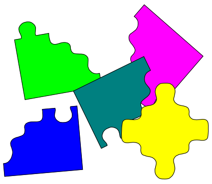
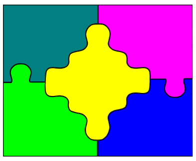
APPENDICES

APPENDIX A PRE-MODULE QUESTIONNAIRE 2004/5



BACHELOR OF EDUCATION
MATHEMATICAL LITERACY FOR EDUCATORS
2004



Name:________________________________ Student Number ____________________

Please fill in the following information

Age:_______years Year in which you finished school________________________

Circle the phrase that best describes your school

Well resourced private school poorly resourced school

adequately resourced school Ex Model C school

Other (specify)_____________

Circle **two** words that best describe your experience of **<u>school mathematics</u>**.

Useful difficult easy relevant fun challenging

humiliating rewarding frustrating irrelevant

Sum up your school experience of mathematics in one or two sentences:

Indicate, with a tick, how much you think each of the factors mentioned influence your ability to do mathematics.

	No influence at all	A slight influence	Moderate influence	Strong influence	Very strong influence
My parent's maths ability					
How much work I do on my own					
The way I am taught					
The personality of my teachers					
How much mathematics my teachers know					
The course materials I am given					
How clever I was born					
My ability to think logically					
My previous mathematics experiences					

Please comment on any other influences on your ability to do Maths.

THIS QUESTION IS FOR STUDENTS WHO **DID NOT** STUDY MATHEMATICS TO GRADE 12 LEVEL
Indicate the extent to which the following factors influenced your decision not to continue with Mathematics to matriculation level.

	No influence at all	A slight influence	Moderate influence	Strong influence	Very strong influence
My parents didn't think I should take Mathematics					
I didn't like the subject					
My teachers discouraged me from doing Maths					
I didn't like the Maths teachers					
I had no choice as Maths was not offered at my school					
I was getting bad marks for Maths					
I didn't think it would be useful for daily living					
My friends were not taking Maths					
I didn't think Maths was required for my career choice					

Please comment on any other influences on your decision not to continue with Maths.

Do you now think you made the correct decision? Explain.

THIS QUESTION IS FOR STUDENTS WHO **DID** STUDY MATHEMATICS TO GRADE 12 LEVEL

Indicate the extent to which the following factors influenced your decision to continue with Mathematics to matriculation level.

	No influence at all	A slight influence	Moderate influence	Strong influence	Very strong influence
My parents thought I should take Mathematics					
I have a love of the subject					
My teachers encouraged me to do Maths					
I liked the Maths teacher					
I had no other choices					
I was getting good marks for Maths					
I thought it would be useful for daily living					
I wanted to be in the class with the clever students					
I thought it would lead to better job opportunities					

Do you now think you made the correct decision? Explain.

How helpful do you find each style of teaching in your learning of Mathematics?

	Not helpful at all	Slightly helpful	Quite Helpful	Very helpful
Private tuition				
Whole class teaching				
Self study from notes or textbooks				
Working in small groups				

Any suggestions for the way this module is taught?

Thank you for your co-operation.

APPENDIX B INTRODUCTORY ACTIVITY 2004

BACHELOR OF EDUCATION
MATHEMATICS LITERACY
FOR EDUCATORS
2004

Group Activity

What would you identify as "gaps" in your maths knowledge and skills?

Which maths topics would you like to re-visit?

What maths do you envisage being useful to you in your daily life?

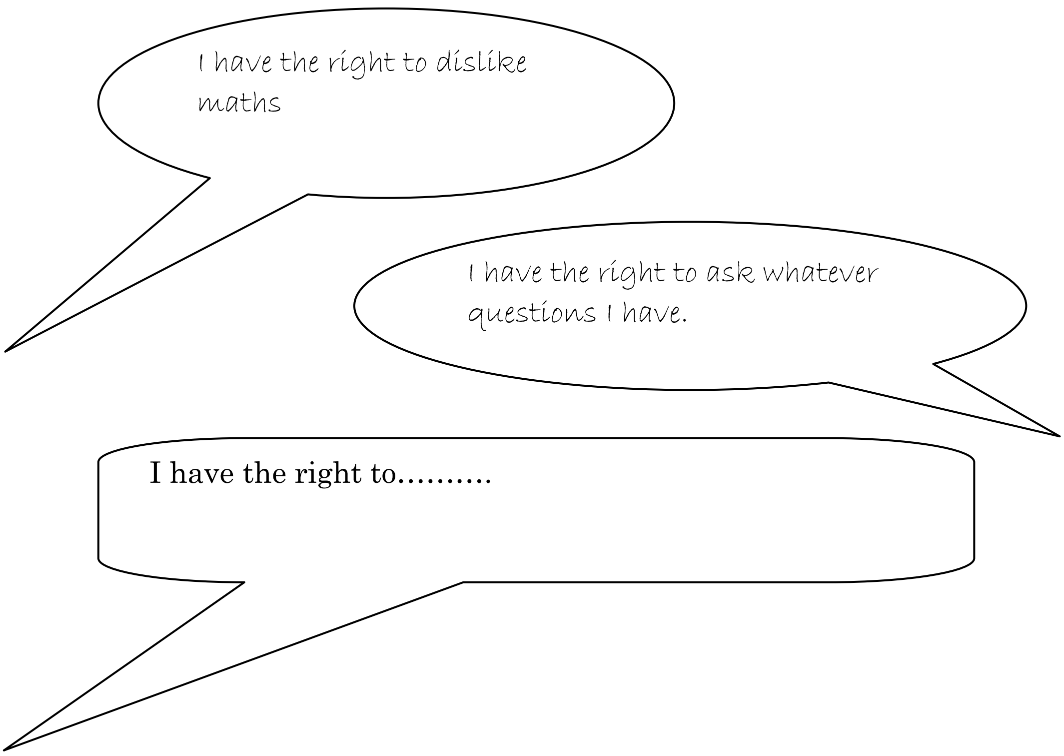
What suggestions do you have for this module? Think in terms of teaching style, (whole class teaching, small groups, independent study from materials etc) and assessment activities.

Sally Hobden 2004

APPENDIX C MATHEMATICS BILL OF RIGHTS ACTIVITY

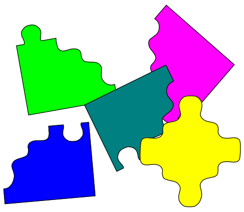
Small Group Activity

- You will given an envelope containing about 15 slips of paper, on which appears a "mathematics right".
- You need to choose 8 of these for your group's charter of rights. You can fill in a blank slip if you can think of a better "right".
- Arrange the slips of paper to form an attractive charter of rights for our maths literacy class. Make sure that your group's names appear on the charter.
- We will look at the charters over the next few days and possibly decide on one the whole group can agree on.



I have the right to learn at my own pace and not feel put down or stupid if I'm slower than someone else.
I have the right to ask whatever questions I have.
I have the right to need extra help.
I have the right to ask the teacher for help.
I have the right to say I don't understand.
I have the right not to understand.
I have the right to feel good about myself regardless of my abilities in maths.
I have the right not to base my self worth on my maths skills.
I have the right to view myself as capable of learning maths.
I have the right to evaluate my math instructors and how they teach.
I have the right to feel relaxed when doing maths.
I have the right to be treated as a competent adult.
I have the right to dislike math.
I have the right to define success in my own terms.
I have the right to
I have the right to

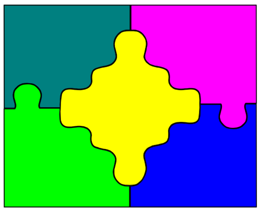
APPENDIX D MATHEMATICS AUTOBIOGRAPHIES



BACHELOR OF EDUCATION

MATHEMATICS LITERACY FOR TEACHERS

2004



Maths and me..(________________)

The story so far…..

APPENDIX E HOW ARE YOU GETTING ON QUESTIONNIARE 2004

BACHELOR OF EDUCATION
MATHEMATICAL LITERACY FOR
EDUCATORS
2004

Name:_________________________________ Number:_______________

How you are getting on with this course?

1 March 2004
Which of the following sentences best describes how you are getting on with this course? Put a big cross in the correct block.

I am managing well and am confident in my ability to do this work depending only on the lectures.	I am battling a bit sometimes but think I will manage with the tutorial lessons as well as the lectures.	Help, I am really not coping at all. I need extra lecture time to help me catch up on my basic skills.

Comments:

APPENDIX F EXPANDED HOW ARE YOU GETTING ON QUESTIONNIARE 2005

BACHELOR OF EDUCATION
MATHEMATICAL LITERACY
FOR EDUCATORS
2005

Name:______________________________ Number:__________________*15 March 2005*

How are you getting on?

Which of the following sentences best describes how you feel you are getting on with this course? Put a big cross in the correct block.

I am managing well and am confident in my ability to do this work depending only on the lectures.	I am battling a bit sometimes but think I will manage with the tutorial lessons as well as the lectures.	Help, I am really not coping at all. I need extra help

Comments:

Which resources did you use to help you prepare for the test? Put a cross in the block of each resource you used.

Notes supplied in lectures	Help offered in voluntary tutorial periods	The material available on the CD	The books on reserve in the library	Help obtained from other students

Comments

How many times have you looked at the CD so far? Put a cross in the most appropriate block.

Never	Just once to see what was there	Three or less times	More than 3 times

Where did you use the CD? Put a cross in the most appropriate block.

In the student LAN on this campus	On my own computer at home	Other (specify)

Please indicate here how you are managing to use the CD.

I am managing fine thank you	I need a little help in going around the parts of the CD	I really have no idea how to use the CD

How many times have you taken out a reserved maths book from the library so far? Put a cross in the most appropriate block.

Never	Just once to see what was there	Three or less times	More than 3 times

Please comment on these aspects of the lectures:

Language used in the lectures

I find the English used in the lectures easy to understand	I can understand the language if I concentrate.	I am battling to understand the language in the lectures

Comment:

Pace – how fast the lecturer goes.

The pace is too slow for me	The pace is fine – I can keep up if I stay on task.	The lecturer goes too fast for me to keep up.

Comment

Learning environment – how you find the lectures as a place to learn.

I find it hard to learn in the lecture theatre	It is generally fine	I enjoy the atmosphere in the class.

Comment

Any other comments about the lectures?

Do you think you would benefit from viewing an edited video of the lectures?

No, once is enough	Maybe if I was absent from the lecture	Yes, it would be helpful

Comments:

Are there any other things that are influencing your learning in this module? Eg. Time to study, work pressure from other subjects, etc.

Thanks for your input. This will be helpful in my preparation for the rest of the module.

Mrs Hobden

APPENDIX G REFLECTION ON DATA HANDLING TEST 2003

Name:____________________

My reflection on the data handling test

1. Think about your preparation for this test, and write a bit about how you prepared yourself, and about how long you spent studying for the test in your own time.

2. Before looking at your mark, write down what you remember as your key areas of difficulty and your key areas of strength when doing the test.

3. Are you pleased or disappointed with your mark? Explain why you think you got this mark.

4. What are your plans to improve your understanding of data handling?

5. How can I help?

6. As we go through some parts of the test that were problematic for many students, try to note down on this yellow page, where you found difficulty in that question.

7. Write down any answers, or references on the white piece of paper that you will keep.

Note: This was shown on an overhead projector and students wrote their responses on plain paper.

APPENDIX H REFLECTION ON DATA HANDLING TEST 2005

Name: Number

24 May 2005

Looking back on the Data Handling test……..

Please answer these questions as honestly and thoughtfully as you can. Your experience in this course is valuable to me in my preparation for the next course

- **What preparation did you do for the test?**

How long did you study?

Where did you study?

With whom did you study?

What resources did you use to study?

- **Did you expect to get the mark you actually achieved?**

Expect to do better?

Expect to do worse?

- Do you think your test mark is a fair reflection of how much you know?

- **What are your study plans in the time before the exam?**

How can I help?

How do you plan to help yourself?

APPENDIX I MODULE EVALUATION AND QUESTIONNIARE 2003

BACHELOR OF EDUCATION

MATHEMATICS LITERACY FOR TEACHERS

2003

Name:______________________________ Student Number ___________________

Please fill in the following information

Age:_______years Year in which you finished school______________________

Circle the phrase that best describes your school

Well resourced private school poorly resourced school

adequately resourced school Ex Model C school

Other (specify)____________

Circle **two** words that best describe your experience of **school mathematics**.

Useful difficult easy relevant fun challenging humiliating

rewarding frustrating irrelevant

Sum up your school experience of mathematics in one sentence:

Circle **two** words that best describe your experience of **this mathematics literacy course**

Useful difficult easy relevant fun challenging humiliating

rewarding frustrating irrelevant

Sum up your experience of this course in one sentence:

Indicate, with a tick, how much you think each of the factors mentioned influence your ability to do mathematics.

	No influence at all	A slight influence	Moderate influence	Strong influence	Very strong influence
My parent's maths ability					
How much work I do on my own					
The way I am taught					
The personality of my teachers					
How much mathematics my teachers know					
The course materials I am given					
How clever I was born					
My ability to think logically					
My previous mathematics experiences					

Please comment on any other influences on your ability to do Maths.

Did you study mathematics to Grade 12 level?____________________

THIS QUESTION IS FOR STUDENTS WHO **DID NOT** STUDY MATHEMATICS TO GRADE 12 LEVEL

Indicate the extent to which the following factors influenced your decision not to continue with Mathematics to matriculation level.

	No influence at all	A slight influence	Moderate influence	Strong influence	Very strong influence
My parents didn't think I should take Mathematics					
I didn't like the subject					
My teachers discouraged me from doing Maths					
I didn't like the Maths teachers					
I had no choice as Maths was not offered at my school					
I was getting bad marks for Maths					
I didn't think it would be useful for daily living					
My friends were not taking Maths					
I didn't think Maths was required for my career choice					

Please comment on any other influences on your decision not to continue with Maths.

Do you now think you made the correct decision? Explain.

THIS QUESTION IS FOR STUDENTS WHO **DID** STUDY MATHEMATICS TO GRADE 12 LEVEL

Indicate the extent to which the following factors influenced your decision to continue with Mathematics to matriculation level.

	No influence at all	A slight influence	Moderate influence	Strong influence	Very strong influence
My parents thought I should take Mathematics					
I have a love of the subject					
My teachers encouraged me to do Maths					
I liked the Maths teacher					
I had no other choices					
I was getting good marks for Maths					
I thought it would be useful for daily living					
I wanted to be in the class with the clever students					
I thought it would lead to better job opportunities					

Do you now think you made the correct decision? Explain.

What style of teaching do you find most helpful and enjoyable in learning Mathematics?

Private tuition   Whole class teaching   self study from notes or textbooks

Working in small groups

Explain why you choose that style of teaching:

Our Mathematical Literacy courses consisted of the following sections.

1. Mathematical Reasoning,
2. Number sense and Computation,
3. Data Handling,
4. Financial maths and
5. Measurement.

Arrange these topics in order, from the one you found the **most enjoyable**, to the one you found the **least enjoyable**. (refer to the topics by number)

Order: most enjoyable _____ _____ _____ _____ _____ least enjoyable

Can you give some reasons for your choices.

Arrange these topics in order, from the one you found the **easiest**, to the one you found the **most difficult**. (refer to the topics by number)

Order: easiest _____ _____ _____ _____ _____ most difficult

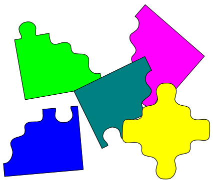
Can you give some reasons for your choices.

Having experienced the course, would you have chosen to do this Mathematical Literacy course if you had had the choice? Give reasons for your answer.

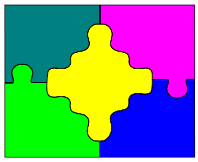
Any other comments or suggestions?

Thank you for your co-operation.

APPENDIX J MODULE EVALUATION 2005



MATHEMATICAL LITERACY FOR
EDUCATORS
2005
Lecturer: Mrs S Hobden



Module evaluation Questionnaire

Name:______________________________ (optional)

In this questionnaire you will be asked your opinion on various aspects of your course for the purposes of evaluation. Student Evaluation is one of the methods used for improving the quality of teaching at the university. This survey will provide your lecturer with valuable feedback about teaching effectiveness. You are not obliged to sign your name and all information is confidential. Please complete as accurately and honestly as possible.

In each section you are presented with a number of statements to which you should respond on the computerised answer sheet. Your possible answers are:
A = strongly disagree B = disagree C = neutral response D = agree E = strongly agree

Fill in your answer on the right hand side of the answer sheet, under answers 1- 45.
Please use an HB pencil or black or blue pen only.

At the end of most sections you are provided with space to write anything extra you want to say.

Please remember to hand in both the computerized answer sheet and this questionnaire.

General

1. In general my background knowledge has been adequate for study in this unit.
2. As a result of studying Mathematical Literacy, I have learnt to think in new ways.
3. My interest in the subject has increased as a consequence of this module.
4. I have enjoyed attending the classes.
5. I have grown and developed personally.
6. I have developed a greater sense of personal responsibility.
7. I have gained more confidence in myself.
8. I would recommend this module to other students.

Lectures

9. I felt confident that Mrs Hobden cares about my progress.
10. I found that Mrs Hobden's lectures are well prepared.
11. I found that Mrs Hobden inspires enthusiasm for Mathematical Literacy.

12. I found that Mrs Hobden makes clear links between the sections.
13. I found that I am always able to understand the language used in these lectures.
14. I found that Mrs Hobden is willing to answer students' questions.
15. I found that the level of difficulty of the lectures is just right for me.
16. I found that the pace of Mrs Hobden 's lectures is just right for me.
17. I think that Mrs Hobden has a good relationship with the class.
18. The use of sexist or racist stereotypes and examples has been avoided.
19. Mrs Hobden has been helpful to both female and male students.
20. Cultural differences amongst students have been acknowledged.
21. Provision has been made for students with language difficulties.
22. A class atmosphere conducive to learning has been maintained.

Write any other comments about the lectures in this space:

Assessment

23. Instructions on assessment tasks were clear and specific.
24. A variety of assessment tasks were provided.
25. I learned from the mistakes I made in the assignments.
26. Tests made me work harder than I normally would.
27. I think that the way my progress is assessed (assignments, tests, exam marks) gives a fair reflection of my understanding and ability.

Write any other comments about the assessment in this space:

Effort and Motivation

28. I believe that if I missed a lecture in this module, my understanding of the work would diminish.

29. I feel that I have devoted an appropriate amount of time to studying this unit.
30. I have utilised all the learning opportunities provided.
31. I have been motivated to do my best work.
32. I have attended classes regularly.
33. I have been encouraged to be responsible for my own learning.
34. I have been encouraged to work independently.

Write any other comments about your motivation to study this module, and the effort you made in this space:

Tutorials

35. I found that it was useful to bring problems that I have in lectures to a tutorial.
36. I found that the tutorials helped me to understand the subject better.

Write any other comments about the tutorials in this space:

Independent Study Resources

37. I found the CD helpful in gaining more understanding of the course content
38. I found the books mentioned on the CD and on reserve in the library helpful gaining more understanding of the course content
39. My computer skills were sufficient for me to make sense of the CD and use it efficiently
40. I was able to borrow the books on reserve without any trouble.
41. I plan to make use of the CD and books during study week
42. Having resources to help me practice the mathematics on my own has been helpful to me.
43. Reading a different explanation of the work on the websites has been helpful.
44. The lecture notes were sufficient for me, I didn't need any extra resources.
45. I plan to borrow the videos of the lectures to help me revise during study week.

Write any other comments about the resources organised for you (the CD, the books on reserve, and the lecture videos) in this space.

Other

Write one or two sentences to describe your experiences in this Mathematical Literacy module:

Thank you for your co-operation

APPENDIX K INTERVIEW INVITATION LETTER -DISTICTIONS 2004

BACHELOR OF EDUCATION
MATHEMATICAL LITERACY FOR
EDUCATORS
2004

Student name

Dear Student Name

Congratulations on passing the mathematical literacy course last semester with distinction. I am very interested in hearing your personal mathematics story, beginning when you were at school and up to the module we completed in June. I am especially interested in hearing about how you account for your personal success and also for the difficulties other students experienced. Your insights will be valuable to me in my research which aims to help student teachers to achieve the mathematical literacy they require for their professional and personal lives. You can choose to speak to me individually or in small groups, at times convenient to you. You could also write me a letter if you would prefer.

Your anonymity is assured, and you have my assurance that any information I gain from the interviews will be used for academic research purposes only.

Please fill in and return the slip below to me and I will contact you early next term to make arrangements. I will put a note in your post box or send an SMS if you have a cell phone.

Your cooperation will be greatly appreciated.

Kind Regards

SHobden.

Mrs S Hobden

Dear Mrs Hobden

☐ I am willing to talk to you about my mathematics experiences.

☐ I would prefer to speak to you privately

☐ I would prefer to speak to you in a small group with ______________________

☐ I am not willing to be interviewed about my mathematics experiences.

I can be contacted by phone at ___________________________.

____
Student Name

APPENDIX L INTERVIEW INVITATION LETTER -PASSES 2004

BACHELOR OF EDUCATION
MATHEMATICAL LITERACY FOR
EDUCATORS
2004

Student name

Dear Student Name

As a student who passed the mathematical literacy course last semester, I am very interested in hearing your personal mathematics story, beginning when you were at school and up to the module we completed in June. I am particularly interested to hear of your successes and difficulties in learning the mathematics. Your insights will be valuable to me in my research which aims to help student teachers to achieve the mathematical literacy they require for their professional and personal lives. You can choose to speak to me individually or in small groups, at times convenient to you. You could also write me a letter if you prefer.

Your anonymity is assured, and you have my assurance that any information I gain from the interviews will be used for academic research purposes only.

Please fill in and return the slip below to me and I will contact you early next term to make arrangements. I will put a note in your post box or send an SMS if you have a cell phone.

Your cooperation will be greatly appreciated.

Kind Regards

SHobden.

Mrs S Hobden

Dear Mrs Hobden

☐ I am willing to talk to you about my mathematics experiences.

☐ I would prefer to speak to you privately

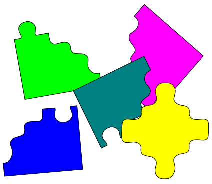
☐ I would prefer to speak to you in a small group with ______________________

☐ I am not willing to be interviewed about my mathematics experiences.

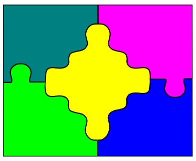
I can be contacted by phone at ___________________________.

____
Student Name

APPENDIX M INTERVIEW INVITATION LETTER -FAILURES 2004



BACHELOR OF EDUCATION
MATHEMATICAL LITERACY FOR
EDUCATORS
2004



Student name

Dear Student Name

I am sure you are as disappointed as I am that you did not pass the mathematical literacy course last semester. I am very interested in hearing your personal mathematics story, beginning when you were at school and up to the module we completed in June, especially the difficulties you may have experienced. Your insights will be valuable to me in my research which aims to help student teachers to achieve the mathematical literacy they require for their professional and personal lives. You can choose to speak to me individually or in small groups, at times convenient to you. You could also write me a letter if you would prefer.

Your anonymity is assured, and you have my assurance that any information I gain from the interviews will be used for academic research purposes only.

Please fill in and return the slip below to me and I will contact you early next term to make arrangements. I will put a note in your post box or send an SMS if you have a cell phone.

Your cooperation will be greatly appreciated.

Kind Regards

SHobden.

Mrs S Hobden

Dear Mrs Hobden

☐ I am willing to talk to you about my mathematics experiences.

☐ I would prefer to speak to you privately

☐ I would prefer to speak to you in a small group with ______________________

☐ I am not willing to be interviewed about my mathematics experiences.

I can be contacted by phone at ___________________________.

____
Student Name

APPENDIX N INTERVIEW INVITATION LETTER -PASSING REPEATS 2004

BACHELOR OF EDUCATION
MATHEMATICAL LITERACY FOR EDUCATORS
2004

Student name

Dear Student Name

I was very pleased to see that you passed the Mathematical Literacy module this year. I am very interested in hearing about your experience of repeating this module, in particular what you found easier or different. Your insights will be valuable to me in my research which aims to help student teachers to achieve the mathematical literacy they require for their professional and personal lives. You can choose to speak to me individually or in a small group of students who also repeated the module, at times convenient to you. You could also write me a letter if you prefer.

Your anonymity is assured, and you have my assurance that any information I gain from the interviews will be used for academic research purposes only.

Please fill in and return the slip below to me and I will contact you early next term to make arrangements. I will put a note in your post box or send an SMS if you have a cell phone.

Your cooperation will be greatly appreciated.

Kind Regards

SHobden.

Mrs S Hobden

Dear Mrs Hobden

☐ I am willing to talk to you about my mathematics experiences.

☐ I would prefer to speak to you privately

☐ I would prefer to speak to you in a small group with ______________________

☐ I am not willing to be interviewed about my mathematics experiences.

I can be contacted by phone at ___________________________.

____
Student Name

APPENDIX O INTERVIEW QUESTIONS 2004

Talk about your experiences of maths at school and now doing the maths literacy course.

Talk about whether your knowledge of maths has changed through doing the maths literacy course

Talk about whether your feelings about maths have changed through doing the maths literacy course

Talk about some of the reasons you see for some students having so much difficulty with the course.

Talk about what made it possible for you to do so well in the course.

Or

Talk about what made it possible for you to pass the course.

Or

Talk about what made it possible for you to pass the course this time around.

or

Talk about what might have made it possible for you to pass the course.

APPENDIX P FOCUS GROUP QUESTIONS FOR CO-WORKERS 2003

You all had the experience of tutoring the first year students doing the mathematical literacy course. My research concerns the knowledge, skills and attitudes these students brought to the course, and how these were influenced by their experience in the course.

1. Comment on the knowledge and skills you perceived these students to possess when you first met them.

2. Comment on the attitudes you perceived in these students towards their mathematical studies.

3. What do you consider the biggest barrier that stood between the students and success in the mathematical literacy course?

4. What suggestions and comments would you like to make regarding the teaching of the course next year?

APPENDIX Q QUESTIONNAIRE FOR CO-WORKERS 2005

Mathematical Literacy for Educators 2005.

Through your involvement with the videoing of the lectures and general assistance in my lectures, you had the opportunity to observe the students and my teaching. I am interested in your impressions of the difficulties you noticed in students learning, and also in which teaching practices you thought useful in promoting better mathematical literacy learning. Please type in your responses on this document and return via email if possible. (Or just write the responses in and give to me if that is easier)

What difficulties do you observe the students experiencing? Try to give specific examples.

Do you think any of the following made a difference in the learning of the students?
Age
Gender
Race
Please elaborate.

When did you observe students learning most successfully? Try to give specific occasions or general types of lessons if that is all you recall.

Any suggestions for teaching this module next year?

Thanks for your input.
Sally

APPENDIX R INFORMED CONSENT FROM STUDENTS IN MLE MODULE 2005

Mathematics Literacy for Educators 2005

Dear Student

Mathematics Literacy is a growing subject in South Africa and will be compulsory at school level from 2006 for learners who do not choose to do formal mathematics for Matric. This means that there is a lot to learn about teaching and learning this subject, and this is a special interest of mine. I have been granted some funding from the National Research Foundation to carry out this research.

In order to conduct research into how people best learn the ideas in mathematics literacy, and to investigate the best way to teach it, I need your permission to use our experiences in this course. I will be asking several of you to come and speak to me in small groups, or individually and I always listen carefully to what you say in class. I also need to keep a record of how you are managing in the tests and activities to see which ideas people find easy to learn and where common areas of difficulty lie. All of this will help me to design and teach a better course next year.

Your anonymity is assured and you have my assurance that the information I gather from this course will be used for academic research purposes only. If you do not wish to participate in this research, you are entitled to say so and then none of your work will be included in my study.

Thank you for your co-operation

SHobden.

Mrs S Hobden May 2005

Name:____

I give Mrs Hobden permission to use the work I do in the Mathematics Literacy for Educators course for academic research purposes.

I understand that I will not be identified by name in any research report and that I am not under any obligation to give this permission. I may withdraw my permission at a later stage if I so wish.

Signed:______________________________________ Date:___________________

APPENDIX S INFORMED CONSENT FROM STUDENTS TUTORS 2004

Teaching Mathematics Literacy 2004

Dear Student

Mathematics Literacy is a growing subject in South Africa and will be compulsory at school level from 2006 for learners who do not choose to do formal mathematics for Matric. This means that there is a lot to learn about teaching and learning this subject, and this is a special interest of mine. I have been granted some funding from the National Research Foundation to carry out this research.

In order to conduct research into how people best learn the ideas in mathematics literacy, and to investigate the best way to teach it, I need your permission to use your experiences in tutoring as part of this course. In particular, this will mean drawing on written reflections, and possibly asking you all to come for a group interview later in the year.

Your anonymity is assured and you have my assurance that the information I gather from this course will be used for academic research purposes only. If you do not wish to participate in this research, you are entitled to say so and then none of your work will be included in my study.

Thank you for your co-operation

SHobden.

Mrs S Hobden June 2004

Name:____

I give Mrs Hobden permission to use the work I do in the Teaching Mathematics Literacy course for academic research purposes.

I understand that I will not be identified by name in any research report and that I am not under any obligation to give this permission.

Signed:______________________________________

APPENDIX T EXTRACTS FROM SUKAR PROJECT PROPOSAL 2004

Proposal for Funding to Develop a Foundational Module in the Bachelor of Education Programme

Proposer: **Sally Hobden**

Course: **Mathematical Literacy for Educators EBD1MLM**

Background and Context

International attention is being focussed on "real world" contextualised mathematics (referred to as numeracy or mathematical literacy) as opposed to the more abstract formal mathematical structures and rigor of professional mathematicians. Advocacy of mathematical literacy is based firstly on the practical value of being able to deal with quantitative situations in personal and work situations, and secondly on the requirement of a certain degree of mathematical literacy in order to function as a responsible citizen in a democracy. In the light of this, few would dispute that all teachers need to be mathematically literate and indeed the South African national policy document, Norms and Standards for Educators prescribes the practical competence of "being numerically, technologically and media literate" (Department of Education, 2000).

The Faculty of Education at the University of Natal decided that a pass in Grade 12 mathematics would fulfill the statutory requirement of numerical literacy, and any preservice teacher (intending to teach subjects other than mathematics at the secondary level) without such a pass would be required to complete a foundational module in Mathematics Literacy. This had implications for teacher education curriculum developers at universities, the mathematics education staff at these institutions, and most of all for the mathematically anxious, mathematically avoidant and generally mathematically unsucessful preservice teachers who were now deemed to be in need of increasing their mathematical literacy skills. The development of this module was a new challenge to faculty staff who had been used to preparing mathematically able students to become mathematics teachers, and now faced the challenge of working with less able students with no prospect of becoming mathematics teachers. This moved the focus away from preservice teacher education towards the challenges of developing mathematical literacy skills in adults. This course is a particular interest of mine, and the subject of my doctoral studies.

The formally expressed purpose of this foundational module in Mathematics Literacy was very much in line with the definition of mathematical literacy provided by the PISA study (OECD, 2000), namely

> The capacity to identify, to understand, and to engage in mathematics and to make well-founded judgements about the role that mathematics plays, as needed for the individual's current and future life, occupational life, social life with peers and relatives, and life as a constructive, concerned, and reflective citizen.

Informally, I emphasised the fact that although the students would never be mathematics teachers, they would nevertheless be teachers who knew sufficient mathematics for their personal and professional lives.

<u>The problem</u>

The course has now run for two years and the pass rate is not very high with many students failing to meet the 40% class mark required for a DP. In my research I identified four main struggles that the students have:

- Struggles to overcome mathematics anxiety and to believe that success in mathematics is a personal possibility.
- Struggles to understand the language used for instruction.
- Struggles to overcome a poor background in basic arithmetic
- Struggles to manage own learning.

A possible way forward

I suggest that students need to develop a sense of independence and purpose in their learning of mathematics, this would increase their confidence and overcome the learned helplessness that often results from a history of failure in mathematics. They need a means of "doing it for themselves". In the course evaluations and interviews, some students have indicated that they find the pace of the lectures too fast, especially if they battle with English. An opportunity to re-experience the lecture electronically in their own time would be helpful. I found that many students were eager to learn the new ideas about statistics for example, and to engage with more sophisticated quantitative literacy debates but their very poor basic skills spoilt all their efforts. When the course ran for the second time, I prepared skills booklets to try to get the students over the basic arithmetic hurdle without holding the rest of the students up unduly. This had limited success and so I showed the group some examples of websites that are available to develop and refine basic arithmetic skills. I suggested that those who were battling take advantage of these and assume some responsibility for their own learning. I very doubt that anybody did, as the most needy students probably have limited computer skills and poor self management of their own learning as well. On reflection, I think the task of finding help and taking control of their learning is too daunting for those students most in need. Providing tutorial help is useful but still ties the student to getting help at a particular time and feeds a sense of dependence on others. There are resources available in the library and online to assist them with basic skills, but they are not easily accessible to naïve students. A bridge needs to be provided between the student and the resources.

Proposal

1. Students are all provided with (or at least have easy access to) a self-help CD.

My proposal is to develop an electronic bank of resources for adult learning of basic arithmetic. I have identified some suitable sites on the web, but there is a need for somebody to spend time carefully searching the web and shareware resources for suitable material, and to put it together in a coherent and understandable form for use by students with limited language and computer skills. I have the ideas and the concept but would need a student (or students) to locate suitable material, and somebody with the computer skills to put it all together. I am envisaging perhaps a basic CD with links to appropriate websites, or even the whole sites downloaded for use off line, a list of really suitable books in our campus library with clear references to each of the sections in the module, and even possibly some video clips explaining key concepts.

2. Key lectures and tutorials are videotaped and written on to DVDs for students to borrow.

This would allow students to listen again to the lecture, to check they have recorded the examples correctly, and to pause the DVD and discuss parts of the lecture. Most modern computers have facilities to play DVDs and DVD players are probably available in many homes, so access should be no problem. More sophisticated add-ons could be Zulu commentary on key points, or a lecturer commentary in English but this is not proposed for the initial run. These DVDs could be used as stand alone study aids or as mediated resources during tutorials.

3. The layout of the lecture notes is revised to include clear links to the resources on the CD and print material.

The course needs to be thought through so that the key mathematical ideas for each section can be checked at the appropriate time. It must be explicit where help on each section is to be found.

I trust this proposal will receive your favourable attention. Please contact me if you need clarification on any of the points raised.

SHobden.

APPENDIX U COMPARISON OF CODES FROM MATHEMATICS AUTOBIOGRAPHIES WITH THOSE IN THE LITERATURE

	Researcher	Coben (2000)	Hauk (2005)	Cooper (1990)	Benn (1997)	Tobias (1993)	Ellsworth (2000)	Poiani (1981)	Moody (2003)
Beliefs about maths as a subject	Prosopopeia usefulness Nature of maths	 The door Invisible maths				 Ambiguity Exactness of answers	 relevance	 Decision making -	
Environmental factors	**Teacher** Teacher sayings Knowledge Classroom practice Professional behaviour Authority figure Facilitator Family Community or school factors	The significant other			Negative comments by teachers		Teacher as authority Teacher as facilitator Comprehension vs coverage Skills and memorisation family Issues of gender	Punishment for not understanding Negative childhood experiences Contagion	Caring teachers Issues of gender & race
Personal factors	Lack of ability Lack of effort Lack of confidence		1 Self evaluation of ability,efficacy and potential			Innate nature of maths ability Self talk Distrust of intuition			
Locus of control	External Internal		Locus of control						
Critical incidents		The brick wall		Cooling out		Suddenness of onset Dropped stitch	Transition from positive to negative	Excessive absence	

APPENDIX V SELECTED STATISTICAL EVIDENCE

Chapter 5
Section 5.1.2 All cohorts Factors affecting ability to do mathematics

Race was a significant grouping variable for the schooling scale

Descriptives

Schooling factors

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
African	126	2.1005	.83215	.07413	1.9538	2.2472	.00	3.67
Asian	14	2.4762	1.03333	.27617	1.8796	3.0728	.67	4.00
Coloured	10	2.4833	1.07281	.33925	1.7159	3.2508	.83	4.00
White	25	2.5600	.78304	.15661	2.2368	2.8832	.33	3.83
Total	175	2.2181	.87038	.06579	2.0882	2.3480	.00	4.00

ANOVA

Schooling factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.300	3	2.100	2.861	.038
Within Groups	125.515	171	.734		
Total	131.815	174			

Multiple Comparisons

Dependent Variable: Schooling factors
Scheffe

(I) race	(J) race	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
African	Asian	-.37566	.24136	.491	-1.0571	.3058
	Coloured	-.38280	.28147	.605	-1.1775	.4119
	White	-.45947	.18758	.116	-.9891	.0702
Asian	African	.37566	.24136	.491	-.3058	1.0571
	Coloured	-.00714	.35472	1.000	-1.0087	.9944
	White	-.08381	.28599	.993	-.8913	.7237
Coloured	African	.38280	.28147	.605	-.4119	1.1775
	Asian	.00714	.35472	1.000	-.9944	1.0087
	White	-.07667	.32056	.996	-.9818	.8285
White	African	.45947	.18758	.116	-.0702	.9891
	Asian	.08381	.28599	.993	-.7237	.8913
	Coloured	.07667	.32056	.996	-.8285	.9818

Gender was a significant grouping variable for the self scale

Descriptives

Self factors

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
male	75	1.6533	.89113	.10290	1.4483	1.8584	.00	4.00
female	116	1.3736	.89135	.08276	1.2096	1.5375	.00	4.00
Total	191	1.4834	.89941	.06508	1.3551	1.6118	.00	4.00

ANOVA

Self factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.565	1	3.565	4.488	.035
Within Groups	150.132	189	.794		
Total	153.697	190			

Race was a significant grouping variable for the self scale

Descriptives

Self factors

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
African	136	1.3873	.86849	.07447	1.2400	1.5345	.00	4.00
Asian	18	2.1111	1.06642	.25136	1.5808	2.6414	.00	4.00
Coloured	11	1.6061	.89217	.26900	1.0067	2.2054	.33	2.67
White	26	1.5000	.80139	.15717	1.1763	1.8237	.00	3.33
Total	191	1.4834	.89941	.06508	1.3551	1.6118	.00	4.00

ANOVA

Self factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.522	3	2.841	3.659	.013
Within Groups	145.175	187	.776		
Total	153.697	190			

Multiple Comparisons

Dependent Variable: Self factors
Scheffe

(I) race	(J) race	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
African	Asian	-.72386*	.22099	.015	-1.3473	-.1004
	Coloured	-.21881	.27620	.890	-.9980	.5604
	White	-.11275	.18859	.949	-.6448	.4193
Asian	African	.72386*	.22099	.015	.1004	1.3473
	Coloured	.50505	.33720	.525	-.4462	1.4563
	White	.61111	.27016	.167	-.1511	1.3733
Coloured	African	.21881	.27620	.890	-.5604	.9980
	Asian	-.50505	.33720	.525	-1.4563	.4462
	White	.10606	.31692	.990	-.7880	1.0001
White	African	.11275	.18859	.949	-.4193	.6448
	Asian	-.61111	.27016	.167	-1.3733	.1511
	Coloured	-.10606	.31692	.990	-1.0001	.7880

*. The mean difference is significant at the .05 level.

School mathematics background was a significant grouping variable for the self scale

Descriptives

Self factors

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Attempted Grade 12	70	1.6762	.83977	.10037	1.4760	1.8764	.00	3.33
Attempted Grade 10 or 1	6	1.6667	.86923	.35486	.7545	2.5789	.33	3.00
Ended at Grade 9	114	1.3392	.90555	.08481	1.1712	1.5072	.00	4.00
Total	190	1.4737	.89163	.06469	1.3461	1.6013	.00	4.00

ANOVA

Self factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.156	2	2.578	3.323	.038
Within Groups	145.101	187	.776		
Total	150.257	189			

Multiple Comparisons

Dependent Variable: Self factors
Scheffe

(I) maths	(J) maths	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Attempted Grade 12	Attempted Grade 10 or 1	.00952	.37471	1.000	-.9151	.9341
	Ended at Grade 9	.33701*	.13376	.044	.0070	.6671
Attempted Grade 10 or 1	Attempted Grade 12	-.00952	.37471	1.000	-.9341	.9151
	Ended at Grade 9	.32749	.36896	.675	-.5829	1.2379
Ended at Grade 9	Attempted Grade 12	-.33701*	.13376	.044	-.6671	-.0070
	Attempted Grade 10 or 1	-.32749	.36896	.675	-1.2379	.5829

*. The mean difference is significant at the .05 level.

Section 5.1.3 All cohorts Reasons for giving up mathematics before Grade 12

Race was a significant grouping variable for the dispiritment scale

Descriptives

Dispiriting factors

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
African	87	1.68	1.084	.116	1.44	1.91	0	4
Asian	10	1.95	1.301	.411	1.02	2.88	0	4
Coloured	6	1.46	1.111	.454	.29	2.62	0	3
White	20	2.58	.990	.221	2.11	3.04	0	4
Total	123	1.83	1.128	.102	1.63	2.03	0	4

ANOVA

Dispiriting factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.154	3	4.718	3.977	.010
Within Groups	141.179	119	1.186		
Total	155.333	122			

Multiple Comparisons

Dependent Variable: Dispiriting factors
Scheffe

(I) race	(J) race	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
African	Asian	-.275	.364	.903	-1.31	.76
	Coloured	.217	.460	.974	-1.09	1.52
	White	-.900*	.270	.014	-1.67	-.13
Asian	African	.275	.364	.903	-.76	1.31
	Coloured	.492	.562	.858	-1.10	2.09
	White	-.625	.422	.535	-1.82	.57
Coloured	African	-.217	.460	.974	-1.52	1.09
	Asian	-.492	.562	.858	-2.09	1.10
	White	-1.117	.507	.189	-2.55	.32
White	African	.900*	.270	.014	.13	1.67
	Asian	.625	.422	.535	-.57	1.82
	Coloured	1.117	.507	.189	-.32	2.55

*. The mean difference is significant at the .05 level.

Type of school attended was a significant grouping variable for the dispiritment scale

Descriptives

Dispiriting factors

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
private school	6	2.67	.376	.154	2.27	3.06	2	3
Poorly resourced school	46	1.58	1.050	.155	1.27	1.89	0	4
Adequately resourced school	34	1.76	1.169	.200	1.35	2.17	0	4
ex Model C school	26	2.38	1.082	.212	1.94	2.81	0	4
Other	11	1.39	1.164	.351	.60	2.17	0	3
Total	123	1.83	1.128	.102	1.63	2.03	0	4

ANOVA

Dispiriting factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17.106	4	4.276	3.651	.008
Within Groups	138.227	118	1.171		
Total	155.333	122			

Multiple Comparisons

Dependent Variable: Dispiriting factors
Scheffe

(I) type of school	(J) type of school	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
private school	Poorly resourced school	1.085	.470	.261	-.39	2.56
	Adequately resourced school	.909	.479	.466	-.59	2.41
	ex Model C school	.292	.490	.986	-1.24	1.83
	Other	1.280	.549	.253	-.44	3.00
Poorly resourced school	private school	-1.085	.470	.261	-2.56	.39
	Adequately resourced school	-.176	.245	.972	-.94	.59
	ex Model C school	-.793	.266	.070	-1.62	.04
	Other	.195	.363	.990	-.94	1.33
Adequately resourced school	private school	-.909	.479	.466	-2.41	.59
	Poorly resourced school	.176	.245	.972	-.59	.94
	ex Model C school	-.618	.282	.315	-1.50	.26
	Other	.371	.375	.913	-.80	1.55
ex Model C school	private school	-.292	.490	.986	-1.83	1.24
	Poorly resourced school	.793	.266	.070	-.04	1.62
	Adequately resourced school	.618	.282	.315	-.26	1.50
	Other	.989	.389	.176	-.23	2.21
Other	private school	-1.280	.549	.253	-3.00	.44
	Poorly resourced school	-.195	.363	.990	-1.33	.94
	Adequately resourced school	-.371	.375	.913	-1.55	.80
	ex Model C school	-.989	.389	.176	-2.21	.23

Section 5.1.4 All cohorts Reasons for continuing mathematics to Grade 12

Race was a significant grouping variable for the affirmation scale

Descriptives

Affirmation factors

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
African	54	1.56	1.011	.138	1.29	1.84	0	4
Asian	9	1.22	.882	.294	.54	1.90	0	3
Coloured	5	2.40	1.362	.609	.71	4.09	0	3
White	6	.72	.534	.218	.16	1.28	0	1
Total	74	1.51	1.033	.120	1.27	1.75	0	4

ANOVA

Affirmation factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.574	3	2.858	2.889	.042
Within Groups	69.253	70	.989		
Total	77.827	73			

Multiple Comparisons

Dependent Variable: Affirmation factors
Scheffe

(I) race	(J) race	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
African	Asian	.340	.358	.826	-.69	1.37
	Coloured	-.838	.465	.362	-2.17	.49
	White	.840	.428	.287	-.39	2.07
Asian	African	-.340	.358	.826	-1.37	.69
	Coloured	-1.178	.555	.222	-2.77	.41
	White	.500	.524	.823	-1.00	2.00
Coloured	African	.838	.465	.362	-.49	2.17
	Asian	1.178	.555	.222	-.41	2.77
	White	1.678	.602	.060	-.05	3.40
White	African	-.840	.428	.287	-2.07	.39
	Asian	-.500	.524	.823	-2.00	1.00
	Coloured	-1.678	.602	.060	-3.40	.05

Race was a significant grouping variable for the affinity scale

Descriptives

Affinity factors

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
African	54	1.88	1.023	.139	1.60	2.16	0	4
Asian	9	.39	.417	.139	.07	.71	0	1
Coloured	5	.80	.908	.406	-.33	1.93	0	2
White	6	.67	.516	.211	.12	1.21	0	2
Total	74	1.53	1.091	.127	1.27	1.78	0	4

ANOVA

Affinity factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25.456	3	8.485	9.660	.000
Within Groups	61.490	70	.878		
Total	86.946	73			

Multiple Comparisons

Dependent Variable: Affinity factors
Scheffe

(I) race	(J) race	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
African	Asian	1.491*	.337	.001	.52	2.46
	Coloured	1.080	.438	.118	-.18	2.33
	White	1.213*	.403	.036	.06	2.37
Asian	African	-1.491*	.337	.001	-2.46	-.52
	Coloured	-.411	.523	.892	-1.91	1.09
	White	-.278	.494	.957	-1.69	1.14
Coloured	African	-1.080	.438	.118	-2.33	.18
	Asian	.411	.523	.892	-1.09	1.91
	White	.133	.568	.997	-1.49	1.76
White	African	-1.213*	.403	.036	-2.37	-.06
	Asian	.278	.494	.957	-1.14	1.69
	Coloured	-.133	.568	.997	-1.76	1.49

*. The mean difference is significant at the .05 level.

Type of school attended was a significant grouping variable for the affinity scale

Descriptives

Affinity factors

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
Poorly resourced school	37	1.96	1.043	.172	1.61	2.31	0	4
Adequately resourced school	26	1.00	.860	.169	.65	1.35	0	3
ex Model C school	5	.80	.671	.300	-.03	1.63	0	2
Other	5	1.60	1.557	.696	-.33	3.53	0	4
Total	73	1.51	1.093	.128	1.26	1.77	0	4

ANOVA

Affinity factors

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16.797	3	5.599	5.584	.002
Within Groups	69.189	69	1.003		
Total	85.986	72			

Multiple Comparisons

Dependent Variable: Affinity factors
Scheffe

(I) type of school	(J) type of school	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Poorly resourced school	Adequately resourced school	.959*	.256	.005	.23	1.69
	ex Model C school	1.159	.477	.127	-.21	2.53
	Other	.359	.477	.903	-1.01	1.73
Adequately resourced school	Poorly resourced school	-.959*	.256	.005	-1.69	-.23
	ex Model C school	.200	.489	.983	-1.20	1.60
	Other	-.600	.489	.682	-2.00	.80
ex Model C school	Poorly resourced school	-1.159	.477	.127	-2.53	.21
	Adequately resourced school	-.200	.489	.983	-1.60	1.20
	Other	-.800	.633	.662	-2.61	1.01
Other	Poorly resourced school	-.359	.477	.903	-1.73	1.01
	Adequately resourced school	.600	.489	.682	-.80	2.00
	ex Model C school	.800	.633	.662	-1.01	2.61

*. The mean difference is significant at the .05 level.

Chapter 6

Section 6.2.1 2004 "How are you doing?" questionnaire

There was a significant difference in the mean MLE score between the group identifying themselves as managing well, and those indicating they were battling a bit.

Group Statistics

	How are you managing	N	Mean	Std. Deviation	Std. Error Mean
Final ML mark	managing well	6	70.67	7.448	3.040
	battling a bit	70	56.86	11.417	1.365

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Final ML mark	Equal variances assumed	1.746	.190	2.900	74	.005	13.810	4.762	4.322	23.297
	Equal variances not assumed			4.144	7.196	.004	13.810	3.333	5.972	21.647

There was a significant difference in the mean MLE score between the group identifying themselves as managing well, and those indicating they were not coping..

Group Statistics

	How are you managing	N	Mean	Std. Deviation	Std. Error Mean
Final ML mark	managing well	6	70.67	7.448	3.040
	not coping	41	53.90	9.828	1.535

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Final ML mark	Equal variances assumed	1.261	.267	3.998	45	.000	16.764	4.193	8.319	25.209
	Equal variances not assumed			4.922	7.810	.001	16.764	3.406	8.877	24.652

Section 6.2.2 2004 cohort module evaluations

Race was a significant grouping variable for the "level of difficulty of work" scale

Descriptives

I was able to cope with the language, pace and level of dificulty in the lectures

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
African	89	3.6030	.74853	.07934	3.4453	3.7607	1.33	5.00
Asian	8	4.1250	.83452	.29505	3.4273	4.8227	2.67	5.00
Coloured	3	3.8889	.50918	.29397	2.6240	5.1537	3.33	4.33
White	12	4.1667	.67420	.19462	3.7383	4.5950	2.67	5.00
Total	112	3.7083	.76343	.07214	3.5654	3.8513	1.33	5.00

ANOVA

I was able to cope with the language, pace and level of dificulty in the lectures

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.995	3	1.665	3.012	.033
Within Groups	59.699	108	.553		
Total	64.694	111			

Multiple Comparisons

Dependent Variable: I was able to cope with the language, pace and level of dificulty in the lectures

Scheffe

(I) race	(J) race	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
African	Asian	-.52200	.27442	.311	-1.3014	.2574
	Coloured	-.28589	.43643	.934	-1.5254	.9536
	White	-.56367	.22864	.115	-1.2130	.0857
Asian	African	.52200	.27442	.311	-.2574	1.3014
	Coloured	.23611	.50334	.974	-1.1934	1.6656
	White	-.04167	.33935	1.000	-1.0055	.9221
Coloured	African	.28589	.43643	.934	-.9536	1.5254
	Asian	-.23611	.50334	.974	-1.6656	1.1934
	White	-.27778	.47992	.953	-1.6408	1.0852
White	African	.56367	.22864	.115	-.0857	1.2130
	Asian	.04167	.33935	1.000	-.9221	1.0055
	Coloured	.27778	.47992	.953	-1.0852	1.6408

Section 6.3.2 2005 cohort module evaluations

Race was a significant grouping variable for the "personal development" scale

Descriptives

I developed personally through this module

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
African	38	4.0132	.70219	.11391	3.7824	4.2440	1.50	5.00
Asian	3	3.6667	.57735	.33333	2.2324	5.1009	3.00	4.00
White	7	3.2857	.48795	.18443	2.8344	3.7370	2.50	4.00
Total	48	3.8854	.70891	.10232	3.6796	4.0913	1.50	5.00

ANOVA

I developed personally through this module

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.281	2	1.641	3.630	.035
Within Groups	20.339	45	.452		
Total	23.620	47			

Multiple Comparisons

Dependent Variable: I developed personally through this module
Scheffe

(I) race	(J) race	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
African	Asian	.34649	.40318	.693	-.6742	1.3671
	White	.72744*	.27652	.040	.0274	1.4275
Asian	African	-.34649	.40318	.693	-1.3671	.6742
	White	.38095	.46392	.716	-.7935	1.5554
White	African	-.72744*	.27652	.040	-1.4275	-.0274
	Asian	-.38095	.46392	.716	-1.5554	.7935

*. The mean difference is significant at the .05 level.

Type of school attended was a significant grouping variable for the "level of difficulty of work" scale

Descriptives

I was able to cope with the language, pace and level of dificulty in the lectures

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Poorly resourced school	24	3.5833	.75020	.15313	3.2666	3.9001	1.67	5.00
Adequately resourced school	11	4.3636	.45837	.13820	4.0557	4.6716	3.67	5.00
ex Model C school	4	4.0833	.91793	.45896	2.6227	5.5440	3.00	5.00
Other	6	3.3889	.90472	.36935	2.4394	4.3383	2.00	4.33
Total	45	3.7926	.79229	.11811	3.5546	4.0306	1.67	5.00

ANOVA

I was able to cope with the language, pace and level of dificulty in the lectures

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.954	3	1.985	3.756	.018
Within Groups	21.666	41	.528		
Total	27.620	44			

Multiple Comparisons

Dependent Variable: I was able to cope with the language, pace and level of dificulty in the lectures
Scheffe

(I) type of school	(J) type of school	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Poorly resourced school	Adequately resourced school	-.78030*	.26468	.047	-1.5519	-.0087
	ex Model C school	-.50000	.39259	.657	-1.6445	.6445
	Other	.19444	.33180	.951	-.7728	1.1617
Adequately resourced school	Poorly resourced school	.78030*	.26468	.047	.0087	1.5519
	ex Model C school	.28030	.42444	.932	-.9570	1.5176
	Other	.97475	.36893	.089	-.1008	2.0503
ex Model C school	Poorly resourced school	.50000	.39259	.657	-.6445	1.6445
	Adequately resourced school	-.28030	.42444	.932	-1.5176	.9570
	Other	.69444	.46923	.540	-.6735	2.0623
Other	Poorly resourced school	-.19444	.33180	.951	-1.1617	.7728
	Adequately resourced school	-.97475	.36893	.089	-2.0503	.1008
	ex Model C school	-.69444	.46923	.540	-2.0623	.6735

*. The mean difference is significant at the .05 level.

Gender was a significant grouping variable for the "culturally responsive class ethos" scale

Descriptives

The class ethos took account of cultural and language differences

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
male	23	3.3043	.99956	.20842	2.8721	3.7366	1.00	5.00
female	24	3.8194	.67372	.13752	3.5350	4.1039	2.67	5.00
Total	47	3.5674	.87894	.12821	3.3093	3.8254	1.00	5.00

ANOVA

The class ethos took account of cultural and language differences

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.116	1	3.116	4.325	.043
Within Groups	32.420	45	.720		
Total	35.537	46			

Section 6.4 All cohorts Final MLE mark

Race was a significant grouping variable for the final MLE mark

Descriptives

Final ML mark

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
African	182	52.18	9.815	.728	50.75	53.62	27	91
Asian	22	54.05	7.669	1.635	50.65	57.45	38	70
Coloured	14	56.64	13.681	3.656	48.74	64.54	30	78
White	28	67.43	10.810	2.043	63.24	71.62	41	92
Total	246	54.34	11.062	.705	52.95	55.73	27	92

ANOVA

Final ML mark

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5720.953	3	1906.984	19.023	.000
Within Groups	24260.042	242	100.248		
Total	29980.996	245			

Multiple Comparisons

Dependent Variable: Final ML mark
Scheffe

					95% Confidence Interval	
(I) race	(J) race	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
African	Asian	-1.864	2.260	.878	-8.23	4.50
	Coloured	-4.462	2.777	.462	-12.28	3.36
	White	-15.247*	2.033	.000	-20.97	-9.53
Asian	African	1.864	2.260	.878	-4.50	8.23
	Coloured	-2.597	3.423	.902	-12.23	7.04
	White	-13.383*	2.853	.000	-21.41	-5.35
Coloured	African	4.462	2.777	.462	-3.36	12.28
	Asian	2.597	3.423	.902	-7.04	12.23
	White	-10.786*	3.277	.014	-20.01	-1.56
White	African	15.247*	2.033	.000	9.53	20.97
	Asian	13.383*	2.853	.000	5.35	21.41
	Coloured	10.786*	3.277	.014	1.56	20.01

*. The mean difference is significant at the .05 level.