The implementation of a mandatory mathematics curriculum in South Africa: The case of mathematical literacy

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I dedicate this dissertation to

Kyriaco & Panayiota

My Parents

My Inspiration to Knowledge and Love

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With many thanks to them all:

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SUMMARY

What happens when teachers are required to implement a mandatory mathematics literacy curriculum whose purposes and pedagogy is distinctly different from that of mathematics curricula of the past? More specifically: How do teachers beliefs and understandings of the curriculum affect the implementation pathway of a mathematics reform intended for ALL?

In 2006 the national Department of Education of South Africa introduced a new curriculum into the mathematics landscape, namely Mathematical Literacy. This curriculum, which is markedly dissimilar in pedagogy, politics and purposes from past mathematics curricula, was introduced as a mandatory alternative to mathematics in the senior secondary phase of schooling; not as an integral component of mathematics curricula but as a unique subject of its own. It recognizes that every adult and therefore every child can and should do some form of mathematics.

This research focuses on the implementation of this new curriculum in a context were mathematical literacy levels are not only unacceptably low among pupils leaving secondary schooling but also among many teachers charged with delivering mathematics education to the learners in South Africa. The three research questions guiding this study are:

1) What do teachers understand to be the purposes, problems and possibilities contained in the mathematical literacy curriculum?

2) How do teachers proceed to implement the mathematical literacy curriculum in their classrooms?

3) Why do teachers implement this curriculum in the ways they do? In other words, what explains the implementation pathways followed by the mathematical literacy curriculum in real classroom contexts?

A review of the literature on curriculum and policy implementation revealed broad encapsulating themes that provide lenses for reform failure. It also provided a perspective that calls for domain specific research. Following on this, the study articulated a broader conceptual framework premised on the perception that a deep understanding of a curriculum is required, for contemporary reforms in mathematical literacy, especially if the goal is to pursue deep change in instructional practices and beliefs. Within this framework, three propositions were generated and then later tested against the emerging data:

Proposition one: Teachers may not have a deep understanding of the purposes, problems and possibilities contained in the Mathematical Literacy curriculum.

Proposition two: Teachers implement the Mathematical Literacy curriculum in their classroom using beliefs and pedagogies that are already entrenched in their practice.

Proposition three: Teachers implement mathematical literacy only because it is a mandatory subject and not because of any strong conviction of the inherent value of this curriculum.

A qualitative research design was used which included two in-depth case studies against the backdrop of a snapshot survey of fifty-four mathematical literacy teachers as an embedded unit of analysis. Using evidence from an array of data collection instruments, the study found that the two educators had a superficial understanding of the intentions of the curriculum both in terms of required pedagogy and purpose of the reform. For both educators the teaching of mathematics in context was outside their paradigm of understanding as was their limited grasp of the 'spirit' of this new reform. What was further revealed was that educators teaching mathematical literacy felt and expressed an overwhelming threat to the status of their professional teaching identity.

The explorative study concludes with implications for future studies and professional teacher development. It also further expands on why a strong theory of action is mandatory if the challenges of complex curriculum change are to be met.

Key words: mathematical literacy, curriculum reform, curriculum implementation, deep change, mathematics in context, theory of action, theory of change, teacher identity, 'spirit' of reform, nature of mathematics

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CHAPTER 1

ORIENTATION AND BACKGROUND

1.1 Introduction

What happens when teachers are required to implement a mandatory mathematics curriculum whose purposes are distinctly different from that of mathematics curricula of the past? More specifically: How do teachers beliefs and understandings of the curriculum affect the implementation pathway of a mathematics reform intended "for all"?

In 2006 all South African children were for the first time required to do mathematical literacy or mathematics in the senior high school grades. This was as a result of the new national curriculum[1], which represents a policy statement for learning and teaching in schools, located in the Further Education and Training (FET)[2] band. The new curriculum is significant in that Mathematical Literacy as a subject is mandatory for all Grade 10 to 12 learners not choosing the subject of Mathematics.

The introduction of this compulsory subject has brought renewed national attention to mathematics reform in South Africa, challenging the mathematics education community to look deeply into the purposes, principles and scope of this reform in order to ensure its successful implementation. The apartheid dispensation, which was responsible for inequitable funding, resources and access to mathematics, left as its legacy a nation with unacceptably low levels of mathematical literacy[3] and mathematics achievement. This curriculum has been developed by the democratic government in an attempt to redress these longstanding inequities, and in so doing has joined a renewed international chorus of voices calling for the accessibility of quality mathematics curricula for all (Leading

[1] *The National Curriculum Statement Grades (NCS) 10-12 (General)* (DoE, 2003a,b)
[2] This band includes Grade 10 through to Grade 12.
[3] See Howie 2002, PISA 2003, SACMEQ II 2000, TIMSS & TIMMS-R 2004.

Maths Success, 2004; NCTM, 2000), and the recognition that every adult and therefore every child can and should do some form of mathematics.

The stated goal of the mathematical literacy curriculum is to enable all learners to become numerate. That is, to give learners the ability to make sense of the world of numbers that surrounds them. It includes enabling them to think numerically with confidence in "order to interpret and critically analyze everyday situations and to solve problems" (DoE, 2003b: 9). This goal is a product of the fundamental principles that underpin this curriculum which are drawn from the new Constitution with an emphasis on human rights, equity and democratic participation. Considering the crisis in mathematics education in South Africa, such a stated goal seeks to fundamentally recast access to mathematics education. Not only will the new curriculum be a challenge to implement due to the lack of resources, both human and material, in the majority of classrooms in the country, it will challenge the beliefs and understandings of teachers who for a long time have considered the teaching of mathematics to be the competence of a few.

The unstated goal behind this policy is more political in nature. In order to serve democratic interests, the new mathematics curriculum has been positioned as "a people's subject, a subject that relates to the context in which people find themselves, a subject that enables people to see and question the unjust" (Bopape & Volmink, 1998:78) and in so doing realizing the needs and wants of "the large numbers of people who voted democracy in the 1994 election" (*ibid.*). Mathematical Literacy as the compulsory alternative to Mathematics would then be the subject offered and taken by the children of those 'large numbers' that voted in democracy.

The challenge for research is to examine how this curriculum will be implemented in the classroom. How will teachers' beliefs and understandings and their enaction thereof affect the implementation of this new curriculum? Early indications of teacher understandings suggest that Mathematical Literacy is been viewed as 'watered down' mathematics or as equivalent to the former Standard Grade Mathematics curriculum[4](Webb & Webb, 2004) Furthermore even those who claim a deeper understanding of the nature of mathematical literacy often do not reflect this in their practice (*ibid*.). Also, a range of problems has already been identified in the implementation process of the umbrella curriculum-Curriculum 2005[5] (C2005) in the earlier grades (Pabale & Dekkers, 2003). The ways in which teacher understandings direct and modify the implementation of the Mathematical Literacy curriculum will have ramifications for the reform of mathematics in South Africa.

The initial research questions that then arise include:

1. What do teachers understand to be the purpose of this reform?

2. How do teachers make-sense of a curriculum that is meant for all?

3. Why would teachers implement this curriculum in the first place?

Add to this core of questions the expected migration of learners from traditional Mathematics to Mathematical Literacy, and the shortage of appropriately qualified teachers in the schooling system, and it is evident that a monumental change in the landscape of secondary school mathematics in South Africa is envisaged. This opportunity for all learners to become mathematically literate requires understanding of how teachers understand and enact this curriculum within the unequal and demanding contexts of schools after apartheid.

1.2 Rationale

> "... If we add to this scenario the fact that Mathematical Literacy is a new subject that has neither been taught before nor completely understood, you will get a sense of how carefully we need to tread" (Minister of Education, 2005).

[4] Subjects in South Africa before the NCS were differentiated into Higher, Standard and Lower grades, based on decreasing levels of difficulty.
[5] C2005 is separated into two bands, Grades R-9 or the General Education and Training Band (GET) and the Further Education and Training Band (FET) for Grades 10-12.

It is often argued that there is a dearth of research on curriculum policy and its implementation in developing countries (Fuller & Snyder, 1991; Verspoor, 1989). However, over the past decade there has been a steady trickle of research related to the link between curriculum policy, practice and achievement outcomes in developing countries, both in general and in the field of mathematics (Amit & Fried, 2002; Bishop & Volmink, 2002; Kyriacou *et al.*, 2002; Mwakapenda, 2002; O' Sullivan, 2002; Rogan, 2003a; SAARMSTE, 2004). What the literature shows is that the implementation problem is often explained in relation to resources, lack of teachers and teacher qualifications, teacher beliefs, emotions and understandings, and teacher knowledge (Coleman *et al.*, 1966; Fuller & Snyder, 1991; Hargreaves, 1998a; Hill *et al.*, *2004*; Lockhead & Verspoor, 1991).

The research however reveals contested views on which variables in fact contribute to better learning outcomes (see Darling-Hammond *et al*, 2001;Hanushek, 1996;Howie, 2005). What does emerge nonetheless is that despite the complexity of the whole (curriculum implementation) it is still the sum of its parts (resources, beliefs, understanding, qualifications, pedagogy etc.). Talbert & Mc Laughlin (1993:188) describes a view of teaching as "permeated by multiple layers of context, each of which has the capacity to significantly shape educational practice". In turn, Spillane (1999) concurs with the view of complexity-ensconcing teacher's reform practices and proposes a 'six P's' model to account for these-personal, public, private, policy, professional and pupil. If on the surface it appears that these parts do not add up, it may be that the importance of one such part has been underscored or is missing altogether.

It is one such gap, that of teachers understanding of mathematical literacy curricula and curriculum policy implementation in developing countries, that constitutes the primary motivation for conducting this study. True, research on teachers understanding of curricula and their effects on implementation exist (see Rogan, 2003b; Sanders & Kasalu, 2004); however, this is not the case for mathematical literacy in developing countries[6].

[6] For the gap between developed and developing countries with respect to learning and achievement see Bloom (1976) and Schiefelbein & Schiefelbein (2004).

As Adler (2004:177) explains," a critical element that has emerged (here) is growing acknowledgements that there is specificity in the mathematical work that teachers do". Sherin *et al* (2004) is of the same mind when they write about the unique characteristics of mathematics as a discipline that stands in stark contrast to social studies. Shulman & Sherin (2004:136) also state, "if reform policy must be 'learning policy' (Cohen & Hill, 2001), then it must also be domain specific". Given, therefore, the paucity of empirical literature on teacher understandings, the introduction of mathematical literacy in 2006 presented an opportunity to explore how such understandings influence the implementation of a compulsory curriculum.

From the perspective of the policymaker, as the capacity to implement a curriculum necessitates a common level of understanding of the reform, not only must every endeavor be made to recognize and explore such understanding of curriculum, but to institutionalize these understandings in the context of the classroom. The exploration of such understanding can then contribute towards the knowledge base on the implementation of mathematical literacy in developing countries, which to date is mostly underpinned by international research from first-world countries (Hargreaves *et al*, 1998b; Matthews, 2005; Mc Laughlin, 1998). Thus, in essence, this research will explore how teachers understand the Mathematical Literacy curriculum, and with what consequences for curriculum implementation. The significance of looking at the teacher as unit of analysis is because, as Hill and Cohen (2000:329) state, "teachers figure as a key connection between policy and practice... and what the policy implies for instruction are both a crucial factor on their practice and at least an indirect influence on student achievement".

Teachers do what they do for complex reasons. Research on teacher thinking and understanding indicates that teachers' personal theories and knowledge are a key basis for classroom practice (Peterson, 1998; Peterson & Clark, 1978; Shavelson, 1976, Shavelson & Berliner, 1988; Yinger, 1979); but the nature of this relationship related to compulsory mathematical literacy curriculum understanding and implementation is poorly understood (Ross et al, 1992). With rare exception (Askew, 1997; Keiser & Lambkin, 1996; Pennell et al, 1996; Pennell & Firestone, 1996), little research on teachers' understanding and interaction with innovative and compulsory mathematical literacy curricula exist. This lack of empirical research further motivated this study.

I will juxtapose curriculum intentions with curriculum enaction. This unfolding of the 'curriculum-in-practice' at the inception of the reform will render a broader understanding of the relations between mathematical literacy curricula and practice in developing countries. In doing this, I provide empirical accounts of how these understandings of purpose; possibilities and problems affect reforms intended for all. The guiding assumption of this research is that to implement a new curriculum of mathematical literacy "for all" requires that teachers have a deep and nuanced understanding not only of content but also of purposes.

A further motivation for this study is more personal. As an educator in senior secondary mathematics for sixteen years and as a Senior Certificate Examination marking moderator, I have repeatedly encountered low levels of proficiency in mathematics amongst teachers and learners alike. I am drawn, therefore to understand why the levels of mathematical literacy are low in South Africa. Contributing factors may include differing levels of teacher understanding of well founded curricula which impact on their instructional practice. Understanding these constraints in reforms targeting teachers is of significance, for as Rousseau & Powell (2005:30) point out, "these efforts inform the design of a system that can better support ALL teachers as they seek to understand change". By providing rich qualitative data this research will then seek to 'inform the design of the system' which is bound to be reviewed in coming years.

When one considers that "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" (Steen, 2005:35) it becomes incontrovertible that mathematical literacy is critical. Given the reality of South Africa joining the global economy and in so doing seeking to empower and numerate its people it becomes a matter of urgency to take a critical look at how this country embraces the mathematical literacy curriculum and to finds ways to develop and promote it. This is the duty of all mathematical stakeholders, including myself.

With this rationale as background, three more defined research questions evolve:

1) What do teachers understand to be the purposes, problems and possibilities contained in a mathematical literacy curriculum?

2) How do teachers proceed to implement a mathematical literacy curriculum in their classrooms?

3) Why do teachers implement this curriculum in the ways they do? In other words, what explains the implementation pathways followed by a mathematical literacy curriculum in real classroom contexts?

The pursuit of the first research question begins with the accumulation of qualitative data with respect to teachers' understanding of curriculum principles, purposes and scope with respect to mathematical literacy.

The second question will probe the discrepancy that may or may not be found between the intentions of the curriculum and the actual enactions in practice. That is, even assuming that the reform was clearly understood among teachers, will their practice reflect such understanding?

The purpose of the last question is to explore why teachers implement the reform. That is, is it because it is official policy to offer it as a compulsory subject, or is it as a result of an understanding and belief of the opportunities it can provide?

My intent is to provide a rich qualitative description of how the Mathematical Literacy curriculum, in varying contexts of re-interpretation, plays out in the classrooms of South Africa. As Hargreaves (1994: x) states:

> Teachers don't merely deliver the curriculum. They develop, define it and reinterpret it too. It is what teachers think, what teachers believe, and what teachers do at the level of the classroom that ultimately shapes the kind of learning that young people get.

1.3 The meanings of mathematical literacy

The concept of mathematical literacy is the subject of widely contested definitions. As this will be a term used throughout this research study, I will briefly present some of this debate in order to clarify the meaning as used in my study.

To begin with, mathematical literacy is often used synonymously with numeracy and quantitative literacy and/or reasoning. The term numeracy itself was first used in the Crowther report in the United Kingdom in 1959, were it was mirrored to literacy (Department of Education, Training and Youth Affairs, 2000). In this report the implication for numeracy was twofold, "on the one hand (it implied) 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 to be problems of kind" (Ministry of Education, 1959:270). In 1998 the United Kingdoms' National Numeracy Task Force (Department for Education and Employment, 1998:11) re-fashioned the definition as follows:

> ...an understanding of the number system, a repertoire of computational skills and an inclination and ability to solve number problems in a variety of contexts. Numeracy also demands practical understanding of the ways in which information is gathered by counting and measuring, and is presented in graphs, diagrams, charts and tables.

Over twenty years later the British Government, in their report on mathematics education, further associated numeracy with an 'at homeness' with numbers in the practical challenges of daily life, and also an 'individual awareness and comprehension of information numbers and data' (Cockroft, 1982).

This need to reframe the meaning of a concept is not unique, for as Dewey (1931:1932) noted, "often change outruns continuity"; accordingly, meanings and definitions must continue apace for, "this is the need of a society that are themselves in a process of constant change" (*ibid*.).

In Australia, the definition is more expansive:

> To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life.
>
> In school education, numeracy is a fundamental component of learning, performance, discourse and critique across all areas of the curriculum. It involves the disposition to use, in context, a combination of:
>
> - underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical and algebraic);
> - mathematical thinking and strategies;
> - general thinking skills; and grounded appreciation of context. (Australian Association of mathematics Teachers Inc., 1997:15)

A comparable interpretation is also articulated by the Organization for Economic Co-operation and Development (OECD) Program for International Student Assessment (PISA); however, PISA uses the term 'mathematical literacy':

> Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to engage in mathematics, in ways that meet the needs of that individual's current and future life as a constructive, concerned and reflective citizen (OECD, Paris, 1999:41).

Closer to home, the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) in the SACMEQ II Project defined mathematical literacy as "the capacity to understand and apply mathematical procedures and make related judgments as an individual and a member of a wider society" (SACMEQ II, 2000). In Botswana, numeracy is included in what it means to be literate: "literacy is the ability to read and write with understanding, in Setswana, English or both; and the ability to carry out simple computations in everyday life" (Republic of Botswana-Ministry of Education, 2005).

Finally, in South Africa Mathematical Literacy in the National Curriculum Statement (DoE, 2003:9) is defined as follows:

> 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 analyze everyday situations and to solve problems.

From these descriptions and definitions above, critical variations in meaning become evident. However, a common thread is that the concept embraces the capacity of an individual to competently manage the quantitative situations of everyday life.

In this study I will use the term mathematical literacy to capture the actual subject of Mathematical Literacy as described in the definition of NCS (DoE, 2003). The implications that the term will carry are that as provided by the South African definition, or more simply put: the ability to critically and competently engage with 'numbers' around oneself.

1.4 The case for mathematical literacy

> “An innumerate citizen today is as vulnerable as the illiterate peasant of Gutenberg's time" (Steen, 1997).

The growing cross-national preoccupation with mathematical literacy skills is driven by studies and reports that show that the lack of numerical competencies negatively impresses upon employment and human development (NFER, 1998; OECD, 1995;

Parsons & Brynner, 1997). Globalization, technology and the information age have made it a necessity for all citizens of the 21st century to be numerate as this provides them with access to full citizenship (D' Ambrosia, 2003).

Goal 6 of the Dakar Framework for Action for the attainment of Education for All by 2015, further recognizes the need for the world's commitment in "improving all aspects of the quality of education and excellence for all so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and life skills" (Unesco, 2000, emphasis added). This goal is been fervently pursued in most first-world countries and emerging economies (United Kingdom, United States, Singapore, Malaysia, Cyprus, Canada The Netherlands etc.) with progressive thinking mathematical literacy strategies and curricula that are adapted and reviewed constantly. In developing countries these ambitions are also beginning to emerge, as in Botswana and South Africa. But as Chimombo *et al.* (1994) advises such ambitions requires long-term strategies and not short-term solutions if capacity building is to be achieved and maintained. It is imperative therefore that the agenda for such reforms should include comprehensive instructional implementation strategies to optimize the use of limited resources.

As indicated earlier, in South Africa the agenda for mathematics reform includes the introduction of Mathematical Literacy as a mandatory alternative subject to Mathematics for Grade 10-12 as from January 2006.An account of the why and the what, has been mandated, follows.

1.4.1 The mathematical literacy crisis-a legacy of apartheid

> “South Africa was again rated last in the Third International Mathematics and Science Study". (HSRC, 1998)

Reports such as the above have come to typify the findings of the 'steady drumbeat' of studies evaluating mathematical competency in South African schools (see PISA, 2003; TIMSS & TIMSS-R, 2004; SACMEQ II, 2000). Common findings in all these studies are that the country's students do not measure up globally in mathematics and mathematical literacy competencies. For example secondary analyses of the South African data generated by the TIMSS study reflect not only a poor picture of performance in reasoning and social utility in mathematics, but also that no obvious improvement has been observed in mathematical proficiency after four years of additional mathematics instruction (Howie, 2002). Also of national concern is that the average age of Grade 12 learners is higher than that of students from other countries and that these students attain poorer results despite the finding that on average they spend more time on mathematics homework than students in other countries (HSRC, 1998). The implications of such results are that school leavers enter the workplace and/or attempt to enter tertiary education without the knowledge and skills required by both.

Recently, national reports of improvement in these results, particularly in the Grade 12 Senior Certificate, are starting to surface. However Kahn (2005) cautions against taking such reports at face value, as often they are politically motivated. The reality is that end-of -school results are still unsatisfactory and reflect deep race inequities.

This is the legacy of nearly five decades of apartheid education, which prohibited black students in South Africa from obtaining quality education in especially the key disciplines of mathematics, science and technology. Even those that were privileged in receiving ‘quality’ education, found themselves on the receiving end of curricula that encouraged rote learning and racism. And so, post-apartheid South Africa inherited a legacy of a nation schooled to be innumerate.

It is these legacies that *The National Curriculum Statement-Mathematical Literacy* seeks to redress.

1.5 The goals of mathematics education and Mathematical Literacy (ML) in South Africa

Mathematical Literacy was entrenched into law as a mandatory subject on the 2nd of November 1998 (Government Gazette, 1998). Also of importance is that whilst new policies and curricula were being put into place, strategies and programs addressing the need for numeracy were also been developed as a commitment by government in improving the status quo. Included in these strategies was The National Strategy for Mathematics, Science and Technology Education, which housed the flagship Dinaledi project (DoE, 2001) and more recently the Thuthuka project (SAICA, 2003). Recent findings have shown both these programs to be making valuable contributions to uplifting numeracy competencies (SAICA, 2007).

All these developments played and continue to play a key role in the establishment of the teaching and learning of mathematics. The NCS Grades 10-12 (General) Mathematical Literacy was introduced in 2003 (DoE, 2003) and is the curriculum response for bringing the government agenda in mathematical literacy and its subsequent policy into the classroom.

1.5.1 A snapshot of the Mathematical Literacy Curriculum

The Mathematical Literacy curriculum supports the application of the nine NCS principles, as follows (DoE, 2003:8, 9):

> 1) Social Transformation
> The prevalence of low levels of numeracy skills among the adult population due to limited and poor education in the past requires intervention to ensure that the trend is broken. Mathematical Literacy seeks to transform this situation.
>
> 2) Outcomes-Based Education
> The focus of Mathematical Literacy is on the development of skills, knowledge, attitudes and values related to the use of mathematics in authentic everyday life situations.
>
> 3) High levels of knowledge and skills for all
> The subject aims to produce mathematically literate citizens who will apply their skills to improve their lives and participate effectively in a democratic society and contribute to developing the economy of the country.

4) Integration and applied competence
Integrated understanding of mathematical concepts is provided for in the holistic view of the learning outcomes.

5) Progression
Assessment standards for each learning outcome imply an increasingly more complex, deeper and broader understanding of knowledge, skills, attitudes and values to be achieved in each grade in the FET band. These go hand in hand with increasingly complex situations in which mathematical thinking must be applied.

6) Articulation and portability
The Learning Outcomes and Assessment Standards for Mathematical Literacy are so designed that they ensure portability between the formal school sector and the colleges or the workplace related learning programs registered on the NQF.

7) Human rights, inclusivity, environmental and socio-economic justice
The subject is designed with the aim of providing access to mathematics for all, through contexts that interest learners and relate to their aspirations.

8) Valuing indigenous knowledge systems
FET learners from the many cultures that make up the school going population of South Africa must be made aware of the mathematics that is embedded in these cultures.

9) Credibility, quality, efficiency and relevance
The teaching of Mathematical Literacy and the choice and the design of support materials will determine the relevance. Parents, learners and institutions for Higher Education will judge the credibility of the subject based on evidence from learners exiting FET.

The role of Mathematical Literacy in these key principles that underpin the NCS, reflect the deep and important role that this subject has to play in the new educational dispensation. This role is further secured and enhanced in the purpose statement of this FET curriculum in that Mathematical Literacy not only contributes to the attainment of critical and developmental outcomes but also forwards capacity building by ensuring that citizens of the future are:

- highly numerate consumers of mathematics;
- self-managing persons;

- contributing workers; and
- participating citizens in a developing democracy (DoE, 2003:10).

These wide-ranging purposes focus on empowering learners with mathematical literacy skills that will enable them to effectively deal with 'number situations' that arise in their developing democracy and the world around them. This is at variance with past mathematics curricula whose main intentions were to differentiate learners in levels of mathematical ability through the teaching of mostly abstract concepts with little or no relevance to context. The pursuit of abstract knowledge and rote regurgitation, although important in several academic tertiary fields did little to develop the knowledge and skills required by all critically numerate consumers.

Furthermore the scope of the curriculum articulates the broadness of what Mathematical Literacy encompasses (DoE, 2003:11):

- use numbers with understanding to solve real-life problems in different contexts including the social, personal and financial;
- use mathematically-acquired skills to perform with understanding financially-related calculations involving personal, provincial and national budgets;
- model relevant situations using suitable functions and graphical representation to solve related problems;
- describe, represent and analyze shape and space in two dimensions and three dimensions using geometrical skills;
- engage critically with the handling of data (statistics and chance) especially in the manner in which these are encountered in the media and presenting arguments;
- use computational tools competently (a scientific calculator is taken as the minimum).

These are all essential conditions for mathematical proficiency. To be achieved, the curriculum recommends, for one, that teachers become 'interpreters of curriculum'. This is essential for as Fullan (2005:9) cautions, "it would be a fundamental misunderstanding of systems theory to assume that the system should change first. Each of us is the system; there is no chicken and egg".

1.6 The significance of this study

The literature on educational change in discipline specific domains is mostly limited to reform efforts in mathematics. For mathematical literacy, scholarly writings include the broadening of the teaching of mathematics and other subjects to contain the competencies required for becoming mathematically literate. However, such accounts do not take into consideration mathematical literacy as a subject domain in itself, particularly in new and emerging democracies.

This study contends that mathematics reform efforts need to be opened up to include the subject of mathematical literacy in order to understand the challenges that teachers implementing this subject are faced with. Furthermore it provides for a theoretical analysis that is different and new for reform efforts in teaching for mathematical literacy.

In advancing a new theoretical perspective on mathematical literacy reforms, I endeavor to augment scholarly understanding and knowledge on the 'curriculum-practice' impasse in educational change settings. I also raise questions related to teachers' sense of their identities as mathematical literacy educators with implications for theory, practice and mandatory curriculum research.

1.7 The limitations of this study

This explorative research entailed two in-depth case studies and an informal snapshot survey of over fifty educators. As the in-depth case studies only involved two respondents, the findings and results may not be generalisable in the usual statistical sense of the word. However, insights gleaned into how the Mathematical Literacy curriculum was unfolding in its first year of implementation in two South African classrooms may offer useful insights and hold valuable lessons for similar classroom contexts.

In addition, the snapshot survey was conducted informally and as such can only be used to provide a preliminary and tentative picture as to how mathematical literacy educators were experiencing the new curriculum.

Another limitation pertains to the conceptual framework. It is too soon to expect a deep change in educators in the first years of implementing a curriculum as the acquirement of understanding and knowledge is a dynamic and unfolding process. However, the deep change illuminates what needs to be done to engender a long term and sustainable sense of education reforms.

The research design was an explorative one and used propositions to define and focus its purpose. As such findings relating to domains outside these propositions may not have come to light.

1.8 Organisation of the dissertation

The complexity of 'connecting the dots' between curriculum intentions and curriculum practice, in mathematics and mathematical literacy reform, will be the subject of the next section.

A synopsis on how the rest of the chapters of this thesis are organized is given in the overview below:

In **Chapter 1** the problem statement, aims and objectives of the study and the rationale have been included. In addition, the background of the Mathematical Literacy curriculum has been discussed as well as an overview on the varying definition of Mathematical Literacy and the general crisis in mathematics education in South Africa.

Chapter 2 gives a report on the literature pertaining to the implementation of mathematics reform curricula, which includes theories and evidence as to why implementation of such reform curricula is a thorny and complex undertaking. The critical synthesis of the literature also identifies the gap that this study wishes to address, namely that of providing empirical evidence for Mathematical Literacy implementation strategies in developing countries, which is found to be crudely lacking. This required specificity is accounted for in the literature synopsis.

In **Chapter 3** I provide a conceptual framework, which takes in the propositions that this study seeks to test. The framework forwarded is that of Deep Change, which describes and explains the need of such change in teachers understanding when pursuing curricula that are distinctly different to those of the past.

Chapter 4 contains the research design and methodology of this study. It also explains the road I took into finding willing respondents for the case study. Furthermore, reasons are given as to why and how this design changed from the time of the research proposal to the time that the actual research was carried out.

In **Chapter 5** I included a snapshot survey of 54 educators that were informally interviewed during the course of this study. Data has also been captured in this chapter of responses from an Internet forum, which was set up to discuss issues pertaining to the new FET Mathematics curriculum. Several subscribers also posed and answered several questions and concerns with regards to Mathematical Literacy on this Internet forum that spoke to the research questions, and as such were included as embedded units of analysis in this explorative study.

Chapter 6 and 7 provides the two detailed case studies (two teachers) presented in narrative form. Included in these reports are biographical background accounts, contextual information, and the themes that emerged in response to the research questions and the propositions of the study.

In **Chapter 8** I conclude with an in-depth analysis of the data by embedding the empirical evidence that was elicited from the study in the Deep Change conceptual framework and extant literature on mathematics reform and implementation. This chapter also further provides recommendations for future research, the significance of this study and also the limitations of this study.

The next chapter provides a critical review on the literature on the implementation of mathematics reforms in the classroom.

CHAPTER 2

The implementation of mathematics reforms in the classroom: A review of the literature

> "There is one thing that distinguishes teaching from all other professions, except perhaps the Church-no change in the curriculum has any meaning unless the teacher understands and accepts it".
> Beeby (1969:154)

2.1 Introduction

The purpose of this chapter is to critically describe the role of the teacher in addressing the implementation predicament of mathematics reforms. In the context of educational change, I review the extensive literature on mathematics and the limited literature on mathematical literacy and present theories and evidence as to why instructional practice is so hard to change. I conclude by arguing that notwithstanding its explicatory significance, there has been no key focus in emerging democracies on how teachers' identities as mathematics educators are impacted upon by new curricula. What is more, there is a critical gap in the literature on teachers' understanding of mathematical literacy reforms.

Momentous designs for mathematics reform are a familiar feature in the literature, but so are reports of failed reforms (Burgher, 2000; Cockroft Report, 1982; Cohen, 1990; Humenberger, 2000; Plowden Report, 1967). This failure is not unique to mathematics education but encompasses a broad range of disciplines. As Fullan (1982:ix) explains," how to get new educational programs to work in practice has increasingly frustrated and mystified those involved in education over the past two decades".

A review of the literature shows a chorus of voices been raised highlighting this unresolved tension between curriculum policy, implementation, and practice, some dating back close to fifty years ago (Havelock & Huberman, 1977;Mc Laughlin, 1998;McCulloch, 1998). This chorus and others include the 'problem' of implementation in both developed and developing countries (Angula & Grant-Lewis, 1997; Frykholm, 1996; Fullan, 1991; Jansen & Christie, 1999; Verspoor, 1989). In mathematics reform, some themes are heard again and again; "And even though reform energy is mostly devoted to mathematics curricula and not numeracy" (Steen, 2001:107) there has been a drive over the past two decades to change such curricula to include numeracy, and/or mathematical literacy, and/or quantitative literacy.

This new wave which emphasizes changing traditional mathematics curricula also echoes several of these tensions as found in countries such as, England, Australia, Canada, the United States, and most recently, South Africa. In these countries, governments have been explicitly pressing an agenda that urges mathematics at school level to be made more socially useful.

The National Council of Teachers of Mathematics in *Principles and standards for school mathematic*s (NCTM, 2000) in the U.S.A. calls for mathematical literacy as a central tenet to mathematics education. In Ontario, Canada (Ontario Education, 2004), publications addressing mathematical issues for 'children at risk' are also looking into the competencies and strategies required for the teaching of mathematical literacy. To better understand quantitative literacy and the educational challenge it presents in the United States, the National Council on Education and the Disciplines (NCED) initiated a national examination of concerns contiguous to Quantitative Literacy education, principally in the framework of school and college studies.

To begin with, NCED published *Mathematics and Democracy: the Case for Quantitative Literacy*, which presented a case statement on the meaning of numeracy as a starting point to the debate (Steen, 2001). The twelve respondents to this debate presented discourse on the central relationships amongst "mathematics, numeracy, and democracy in the changing world of the twenty-first century"(Orrill in Steen, 2001: xviii). A point of coherence in these dialogues was that attempts to deepen and strengthen mathematics curricula "do not necessarily lead to increased competency with quantitative data and numbers" *(ibid.)*.

To further develop this conversation NCED funded a national forum, *Quantitative Literacy: Why Numeracy Matters for Schools and Colleges*, held at the National Academy in Washington, D.C. on December 1-2, 2001.This forum's key results concentrated on the need for quantitative literacy both as a personal and societal concern (Madison & Steen, 2003). It looked at matters of curriculum design in terms of inclusion and grades; it questioned policy challenges such as: articulation, assessment, relation to mathematics, core curriculum, and it also called for stronger mathematical education of teachers, policy perspectives and also for stronger curricula, and institutional policies in secondary and tertiary education (*ibid*.).

In South Africa this tenet is even more explicit, in that Mathematical Literacy is a compulsory alternative to Mathematics. Furthermore, it is a new subject offering and not a 're-curriculation' of the cognately close and already established school subject of Mathematics.

In addition, recent literature on the need of this progressive reform includes amongst others writings from Mogens Niss of Denmark, Michel Merle of France, Geoffrey Howson of Britain and Ubiratan D'Ambrosio of Brazil. This focus on mathematical literacy as a reform has been spurned by the numerous international studies[7] that are placing an emphasis on mathematical literacy as an area of concern distinct from the traditional mathematics curricula. The distinction or relationship between mathematical literacy and mathematics knowledge and skills depends on how mathematics is defined. A broad partly sociological and partly epistemological perspective by Niss (1994) perceives mathematics as a field possessing a five folds nature: as a pure, fundamental science; as an applied science; as a system of tools for societal and technological practice; and as a field of aesthetics. In this non-restrictive definition mathematical literacy "is more or less the same as the mastery of mathematics" (Niss in Steen, 2001:216). There is also literature and definitions that pronounce that quantitative literacy and mathematics are really "two quite different things" (Cohen in Steen, 2001:23). However, as the

[7]See: International Adult Literacy Survey (IALS) (OECD 1995);OECD through its Program for International Student Assessment (PISA) whose major focus in 2003 was mathematical literacy (NCES 2002); Adult Literacy and Life skills Survey that took place in 2002 and 2003 &TIMSS-R (1999).

curriculum is normally one, a literature review can not but includes the broader discipline of mathematics in a review of mathematical literacy.

There is also a widespread agreement in providing explanations for reform implementation to look in the direction of the teacher, for teachers are the 'final brokers' when it comes to implementing policy and enacting curricula (Fullan & Hargreaves, 1992; Mc Laughlin, 1987, 1990; Sarason, 1995; Wideen, 1992).

2.2 Implementing Agents

Fullan (1991) concurs with the importance of the teacher, for he explains that successful reform necessitates teachers that are ready to change, and teachers that have the required resources to implement and sustain change. Additionally he describes reform to be local and restricted by the 'ownership' that teachers ascribe to it in the classroom. Such accounts are important for they elucidate the non-linear relationship between curriculum and classroom practice that is often ignored by policy planners. Hopkins *et al*. (1994:17) note:

> It is almost always the case that centrally imposed (or top-down) change implicitly assumes that the implementation is an event rather than a process; that a change proceeds on autopilot once the policy has been enunciated or passed. This perspective ignores the critical distinction between the object of change...and the process of changing-that is how schools and agencies put the reforms into practice.

Analyses of the tension in the implementation themes that emerge in mathematics reform include problems arising in connecting, the knowledge of mathematics, the knowledge of the didactics of mathematics and pedagogical knowledge and, the mathematics education of teachers to the reform (Ball, 1988, 1990; Hill et al, 2004; Manouchehri, 1998; Sherin, 2002; Shulman & Grossman, 1988; Thompson et al, 1994). These findings substantiate the impact of the role of teachers' content and pedagogical content knowledge in creating and sustaining instruction promoting student discourse and in teaching for conceptual understanding, which are important elements for the successful implementation of new waves of quality mathematics curricula.

2.2.1 Professional Development and Knowledge

In mathematical literacy similar tensions resonate. Romberg (2001:8) states that the function of "professional development in helping teachers to develop their own classrooms to promote understanding and how the school supports (or impedes) the work of teachers in developing and sustaining these classrooms; and how non-school agents (such as parents), agencies (district), and their actions support (or impede) the development of these classrooms" is imperative in understanding the implementation of mathematical literacy reforms. Schoenfeld (2002:17) in an analysis of the Pittsburg Data on the NCTM *Standards* based reform is of a similar opinion when he asserts, "reform appears to work when it is implemented as part of a coherent system effort in which curriculum, assessment, and professional development are aligned". Consequently "not only do many more students do well, but the racial performance gap diminishes substantially" (*ibid*.). Such suitable professional development is not only required in secondary schools but also in primary schools that seek to implement numeracy strategies successfully (NNS, 1999). Such training necessitates more than developing and educating teachers on the needs of a reform; it also requires similar execution in the development of leadership, the absence of which has shown to significantly negatively impact on implementing reforms as intended by policy and curricula (*ibid*).

On the issue of content and pedagogical knowledge Steens' (2001:89) words "that a teacher's knowledge of content seldom guarantees that he or she can structure and communicate that knowledge in ways that enable a diversity of learners (particularly those that are compelled to attend classes) to understand and apply the knowledge that has been learned" become imperative in structuring the above mentioned staff development programs. Such comments even though contested in mathematics (see Adler, Slonimsky & Reed, 2002; Brodie, 2004;Monk, 1994; Rowan, Chiang & Miller, 1997) remain scarcely addressed in mathematical literacy. Mainly because, teacher subject knowledge of ML is largely taken as an extension of subject knowledge in mathematics.

The teaching of mathematical literacy is however a deviant progression from traditional mathematics curricula which brings into focuses the levels of subject knowledge both content and pedagogical that are required for its teaching. This intensifies the quandary on who is best suited to edify mathematical literacy and, as Steen (2001:46) observes, what "mathematics background might or might not be best suited for the teaching of quantitative literacy ". It is important however to note that here the implication is not that a weak subject knowledge is favored, not only as an intuitive appraisal but also as evidenced in the empirical findings of the Ofsted Publications (NNS, 1999), but that traditional, strong subject knowledge of teachers does not necessary translate to better student achievement or aligned curriculum implementation.

Further implementation tensions arise through the non-use of curricula and policies as intended. In an assessment of the *Standards* reform in the U.S.A., Briars and Resnik found that "weak implementers were either not using the curriculum at all, or using it so little that overall instruction in the classroom was hardly distinguishable from traditional mathematics instruction" (Briars & Resnik, 2000:6). This limited and surface use of curricula documents is further exaggerated during instructional assessment, as teachers do not align assessment practice with curriculum intentions. What is required is an employment of, "rich, varied, and effective assessment strategies for students at risk in mathematics" (Ontario Education, 2004:89). The absence of which is either due to a lack of curriculum understanding or an absence of supportive staff development strategies in the face of strong and variant theories of change (NNS, 1999; Schoenfeld, 2002).

Beyond these matters of content and pedagogy for teachers' enactment of curriculum in the classroom are questions concerning the 'black box' of teaching established within the classroom context (Mc Laughlin, 1998).

2.2.2 'Black Box'

It is a common goal of this new genre of addressing implementation issues, to promote the building of an awareness of the teachers beliefs, attitudes, values and understanding of the nature of the reform, and in doing so enable the engagement of the often difficult and complex work of how teachers make-sense of a new curriculum. There is also an additional area within this genre that remains narrowly researched in educational change, namely that of self-awareness or identity (Allen, 2005).

To begin with, beliefs and attitudes are a broad encompassing domain and deal with self and society.

2.2.2.1 Attitudes and Beliefs

Teacher attitudes and beliefs[8] to mathematics reforms have been studied and researched and found to contribute to the affectivity of mathematics education. This focus of interest has grown in the larger mathematics community in the last three decades since the founding of *Psychology of Mathematics Education* (PME) (Gutierrez, Boero, 2006).

A major research study in England, namely the *Effective Teachers of Numeracy Study* graded teacher efficacy according to student gains in tests (Askew, Brown, Rhodes, Johnson, & William, 1997). Teachers' underlying beliefs about teaching and mathematics were found to be compelling discriminating factors between highly effective teachers and those not charged likewise. Such findings are further substantiated in the *Standards* reform were a similar 'implementation pitfall' was identified, with the report on the critical issues surrounding this reform maintaining that (www.ncrel.org, 1995):

[8] "Defining beliefs is at best a game of player's choice. They travel in disguise and often under alias-attitudes, values, judgements, axioms, opinions ,ideology, perceptions, conceptions, conceptual systems, preconceptions, dispositions, implicit theories, explicit theories, personal theories, internal mental processes, action strategies, rules of practice, practical principles,perspectives,repertoires of understanding, and social strategy, to name but a few that can be found in the literature"Pajares (1992:2).Drawing on the work of Dilts (1999) ,I will define beliefs (in this dissertation) as judgments and evaluations that teachers make about themselves and their teaching.

> The area where reformers are most likely to run aground in bringing about change is the task of building consensus on the beliefs and values that should guide the teaching and learning of mathematics. An additional implementation pitfall is related to the pervasive practice of teaching the procedures of mathematics detached from the meaning and applications of these procedures.

Furthermore, Romberg (2001:8) claims that, "the complexity of instructional issues involving creating classrooms that promote mathematical literacy include amongst others the normative beliefs within a classroom about how one does mathematics". What complicates research on beliefs however is not only that they are wide-ranging based on personal and societal constructs but also that like attitudes they are difficult to measure and ascertain. Nonetheless, this difficulty does not preclude the importance of aiming to develop in students' positive attitudes towards mathematics that are derived from teacher's attitudes (Cockcroft, 1982). This line of inquiry into beliefs and attitudes in teachers teaching for mathematical literacy is underdeveloped, particularly in democratically developing countries, like South Africa, where mathematical literacy is being introduced as a unique discipline and not as an integral component of the core mathematics curriculum. Likewise, so is teacher understanding of mathematical literacy curricula.

2.2.2.2 Understanding

The importance of understanding as a condition that can contribute to educational innovation was recognized in the seventies by Gross *et al* (1971) .The lack thereof, or what he termed,' lack of clarity about the innovation' he found to be a factor to implementation failure. McLaughlin & Marsh (1978) established that the acquisition of such conceptual clarity couldn't be given to staff at the beginning of the reform, as it is something that evolves during the implementation phase. What it evolves to is dependent on frames such as 'career stage', 'career stories' and 'structural contexts' in which teachers are situated (Ball, 1997; Drake *et al*, 2001; Schifter, 1996). These frames have in recent studies been shown to contribute to reform success in both developed (Macnab, 2003) and developing countries (Pabale & Dekkers, 2003; Sanders & Kasalu, 2004).

The predispositions and understandings that teachers hold are both consciously and unconsciously replicated in their own classrooms during their teaching.Teachers identify with teaching in the way that they were taught (Borasi, 1990). Gellert (1999:22) reported, "In mathematics education research, it seems to be undisputed that the teacher's philosophy of mathematics has a significant influence on [their] mathematics classes". Studying pre service elementary teachers in Germany, he found that teachers' "learning experiences exert a tremendous influence on their design of mathematics classes" Gellert (1999:27). As teachers seek to embrace a new reform they "reach out with their old professional selves, including all the ideas and practices comprised therein" (Cohen, 1990:339). Instead of changing conventional practices the common response for reform has been the 'nominal ' adoption of the reform ideas (Romberg, 2001:8)

Spillane (1999:159) has coined the term 'zone of enactment' to refer to "the space in which [teachers] make sense of, and operationalize for their own practice, the ideas advanced by reformers...differences in teachers' enactment zones are key in understanding their efforts to change the core of mathematics instruction". He further states that, "the new ideas about practice that teachers encounter through the policy and professional sectors can only work in and through teachers existing knowledge and beliefs" (169). These findings are consistent with those of Romberg (1997), and Cohen & Ball (1990).

In mathematical literacy education, a widespread misconstruction amongst teachers is that pupils have to master mathematical algorithms and skills before using them for applications and problem solving. Teachers, who understand the curriculum and required pedagogy as such, focus first on these mathematical skills, assuming that problem solving and the understanding of 'mathematics in context' will follow. The result is the falling back on teaching the traditional curriculum due to the use of traditional methods (Schoenfeld, 2002). This understanding is difficult to change, as it is different to that common to mathematics practice. Hughes-Hallett (in Steen, 2001:94-96) explains this as follows:

> Mathematics is about general principles that can be applied in a range of contexts, quantitative literacy is about seeing every context through a quantitative lens...The reason that quantitative literacy is hard to learn and hard to teach is that it involves insight as well as algorithms. Some algorithms are of course necessary-it is difficult to do much analysis without knowing arithmetic, for example. But algorithms are not enough; insight is necessary as well. Insight connotes an <u>understanding</u> of quantitative relationships and the ability to identify those relationships in an unfamiliar context (*emphasis added*).

Romberg (2001:8) further concurs with the difficulty of this when he claims "non-routine patterns of instruction that allow students to become mathematically literate are not easy to create". A foremost raison d'être for this is that "teachers must be agents of change that they did not experience as students" (Anderson & Piazza, 1996) - teaching and learning with the use of context, to successfully problem solve.

Carraher, Carraher, & Schliemann (1985) observed Brazilian children solving numerical problems as they sold produce on the street. These same children failed to solve the same problems when they were presented out of context in traditional mathematical form. This observation, amongst others, supports the work developed over the last two decades on situated cognition (see Brown, 1989;Collins, Brown & Newman,1990 & Lave, 1988),which focuses on how situations and contexts co-construct knowledge . Closely linked to this work is the work by Etienne Wenger (1998) on *Communities of Practice*, which sees learning as an active co-participation process for students. These views of learning knowledge and skills in contexts that mirror the ways they will be used in real life require an understanding by teachers which may not be within their current pedagogical paradigms.

Cohen's (1990:327) case study of a single mathematics teacher's classroom led him to the following paradox:

> How much can practice improve if the chief agents of change are also the problem to be corrected? This paradox would be trivial if fundamental changes in learning and teaching were easy to make. If...it is implausible to expect students to understand math simply by being

> told, why is it any less implausible to expect teachers to learn a new math simply by being told?

This paradox is deep-seated for it underscores the inconsistency that often exists in reforms. Quality instructional curricula are designed and their implementation is considered to be linearly linked to the written word. However this is often not the case. In a study in four Colorado school districts implementing Standards-based mathematics reforms, Haug (1999) found a 'great variability' in the understandings teachers held about the reform. Similar findings of variance are also characteristic of mathematics reform research in the work conducted by Hill (2001) and Spillane & Zeuli (1999). Understanding, as Drake (2002:314) describes, is a complex issue, one which is "framed by who [teachers] are as learners and teachers of mathematics". It is essential then, in implementing the blueprint of a curriculum, to have a clear understanding of the intentions of the written word in order to change entrenched classroom habits. Allowing time for reflection and discussion become important during the implementation process, for it is here, in the classroom that the curriculum begins to develop. What it develops to is dependent on what is in each teacher and how the external forces available shape his or her extant knowledge.

Response to reforms is thus further situated in the cognitive domain, additionally compounding the complexity of implementation. Spillane *et al* (2002:393) explain this as follows:

> What a policy means for implementing agents is constituted in the interaction of their existing cognitive structures (including knowledge, beliefs, and attitudes), their situation, and the policy signals. How the implementation agents understand the policy's message(s) about local behavior is defined in the interaction of these three dimensions.

What surfaces, in such research is that a multitude of curriculum interpretations exist depending on prior held beliefs and understandings. This may result in comprehending such research as only significant from the individual lens, with no real validity in informing curriculum design. Such an interpretation would be to miss the broader picture. For even though such work may seem to propose an infinite number of interpretations what is of importance are the patterns that manifest themselves as the more dominant. The variables that create these patterns can then be identified and clustered and used to inform the design process. In this way 'demystifying' these more nuance variables.

Understanding has recently also included what has come to be known as the 'spirit of a reform'. The spirit resonates with grappling with the purpose and process of the reform, which is paramount in 'changing what counts'. This has been found to be habitually not understood or neglected in its entirety (Chisholm, 2000; Spillane, 2000). In the link between mathematics and statistical literacy Burrill (2003:52) found that in teacher training workshops "teachers understand the process but not the spirit involved in the materials and techniques". In the *Standards* reform the 'key question to be addressed' amongst the requisite actions to be taken to ensure a more congruent and successful implementation is the integration of the 'spirit of the *Standards* into classroom practice' (Cook, 1995). This facet is insightful and relevant, for new mathematics reforms. For in exploring teachers' understanding of the purpose and process of mathematical literacy the lens for implementation issues may be widened and as such, strengthened.

This may also be realized by exploring the impact that new mathematics reforms have on teachers' sense of their identities as mathematics educators.

2.2.2.3 Teacher Identity

The construction of teacher identities is a complex issue as it entails not only narratives teachers read in official documents such as policies and curricula about the roles that they should be fulfilling, but also narratives that they hear in the public domain (Soreide, 2007). In addition, "The structure and culture of schools have been some of the most powerful factors which have shaped teachers' identity" (Dinez-Pereira, 2003:3).

These narratives in mathematical literacy are seldom heard with regards to teacher identity and educational change, for mathematically literacy reforms are normally an integral part of the mathematics curriculum or are integrated in other disciplines. In South

Africa recent findings showed that "teachers' retrospective subject-centered professional identities were incongruent with prospective official identities constructed by MLMMS" (Mathematical literacy, Mathematics and Mathematical Sciences) "(Naidoo & Parker, 2005:67), a new mathematics curriculum introduced in the General Education and Training Band of Curriculum 2005.It was found that one major contributing factor was that staff development programs were not doing enough to "resocialise teachers into a new subject loyalty" (Bernstein,1971:56). Such evidence on the role that mathematical literacy curricula play in shaping teacher professional and status identities, or in re-shaping mathematics teachers' identities is scarcely researched. This may be more pronounced and therefore profound in developing countries were scarce qualified mathematics teachers enjoy considerable status within the school and the professional community.

Goodenough (1963:217) described seven conditions needed for identity change:

- one desires an identity change,
- one commits to that change,
- one understands what needs to be changed,
- one knows the roles and symbols of the new identity,
- one has the ability to perform new roles,
- one has the new identities recognized and accepted by others, and
- one conceives of oneself as having changed identity.

Allen (2005) cites that these conditions apply well to career changers. It may be found that in South Africa, the introduction of the mathematical literacy curriculum in secondary schools as a distinct and separate discipline to mathematics may require a similar understanding and learning of the impact this curriculum will have on mathematics teachers', professional identities. In conclusion, for teachers to be able to implement change I concur with Harley and Parker (1999) that posit that "teachers may well need first to shift their own identities, their understanding of who they are and how they relate to others"(p.197).

Collectively such analyses point to the complexity of the process between publication of proposals for curriculum change and their successful and long-term implementation. In a study of curriculum reform in mathematics, science and technology among 13 OECD countries Black & Atkin (1996:189) concluded that; "the perspectives on educational change which have emerged are complex and multiple". This complexity is further evident in a variety of frameworks that have been proposed in an effort to make available explanations for the implementation problems teachers' face in reform attempts.

Spillane's (1999) "six P's" model argues that the public, private, policy, professional and pupil subdivisions all operate to form the teachers' personal response to and implementation of reform in mathematics. Similarly Talbert & Mc Laughlin (1993:183) has expressed a "view of teaching as permeated by layers of context, each of which has the capacity to significantly shape educational practice". Tate (2004), on the other hand, argues that student 'opportunity -to-learn' is related to issues of 'time',' quality' and 'design'. Such explanations are not all encompassing and at times in contradiction with findings of other researchers. What is of importance though is that they provide an analytical lens through which implementation questions and inconsistencies can be addressed, particularly in developing countries (Mwakapenda, 2002; O'Sullivan, 2002;Rogan, 2003) were such implementation issues; particularly in mathematics equity reforms are addressed tangentially, if at all.

2.3 Teaching Context

What is often further ignored is also the context in which teachers work. Shulman & Sherin (2004:136) explain this as follows:

> ..., it is one thing to focus generally on how disciplinary understandings and teacher development interact. There are few examinations of how these factors interact in the context of a specific classroom-and pedagogy-centered school reform.

Numerous other authors have expressed a similar view for the significance of context in the implementation process. Their findings consistently show that successful implementation ultimately depends on the extent to which planners take 'classroots realities' into account (Fullan, 1991; Havelock & Huberman, 1977; Henevold & Craig, 1996; Lockheed & Verspoor, 1991). Mc Laughlin (1998) goes as far as saying that to ignore context is to ignore the very elements that make policy implementation a 'problem'. Such observations are vital for they provide empirical evidence for why quality instructional curricula often fail. What is more is that the examination of the context must be domain-specific. That is, mathematics reform for example, must be viewed in a mathematics context and classroom (Cohen & Hill, 2001; Lampert, 1990). This is because even though disciplines may have a lot of commonalities they also have a lot of variance. In the literature there is paucity in looking into mathematical literacy classrooms mainly because the discipline of mathematical literacy, as previously mentioned is rare as an entity of its own.

O'Sullivan (2002:222) has usefully divided the 'classroots realities' identified in the extensive general literature into 'objective' and 'subjective' implementation factors. Objective reality factors include; resources, professional capacity, support services, personal obligations, location of school, principal capacity, communication networks, learner capacity and political influence. The subjective reality list includes: relevance, desirability, motivation, attitudes/perspectives, feasibility, realism, complexity and, culture.

2.3.1 'Objective Realities'

The objective realities are particularly pronounced in developing countries, such as South Africa, and in minority groups where resources and capacity are often lacking. Properly qualified teachers in mathematics instruction in high-poverty classes are a common denominator the world over, which negatively impacts reform initiatives (Arnott *et al*, 1997; Darling- Hammond, 1997; Weiss, 1994). This is because poorly qualified teachers often provide low-level access to high-level content and reform-based mathematics pedagogy (Lubienski, 2002; Oakes, 1990). Time factors, quality factors and design as put forward by Tate (2004) are further additions to the objective realities list of mathematics instruction. And even though not all of these factors are agreed upon by other researchers[9] as either influencing student outcomes or contributing significantly to implementation failure, the examination of these with respect to 'opportunity-to-learn' is useful, for as Tate (2004) suggests it informs the design of a more effective and equitable system.

To ignore resource shortages and to seek only more rich qualitative descriptions of reform initiatives is not an option for the reality is that capacity is severely underdeveloped in many countries seeking to make ambitious changes. These conditions capture a significant proportion of the inequities that prevail in access to quality mathematics for all (Berry, 2005; NCTM 2000). What is however clear that is the objective reality taken alone does not exhaustively account for implementation failure.

2.3.2 'Subjective Realities'

The 'subjective realities' are on a more of a social level. That is the contexts within which teacher's work significantly impinge on their readiness and capability to assimilate pioneering methods and materials in their classrooms. Teachers' personal constructs and beliefs related to teaching, learning and students' needs are central to how they bring into play mandated mathematical reforms, but again the social foundations within which they work influence these personal theories. Battista (1994:462) pointed out that," teachers are key to the success of the current reform movement" and that "many teachers have beliefs about mathematics that are incompatible with those underlying the reform effort". Beliefs and attitudes are of particular importance in reforms that are intended for all, for as Nieto (1998:413) explains, "Until societies believe and act accordingly to the belief that all children are worthy and capable of learning, most students of non-dominant groups will be doomed to academic failure".

In some instances, as in South Africa, the groups doomed to academic failure were the dominant groups due to the belief held by educational stakeholders that indigenous South

[9] E.g. For the effects of class size see Howie (2005), and for teacher qualifications see Fuller & Snyder (1990).

Africans were incapable of making decisions and shaping their own educational destiny. An example of such an extreme belief can be seen in a speech given in 1953 by the then minister of Native Affairs Dr. H.F.Verwoed:

> When I have control over native education I will reform it so that the natives will be taught from childhood to realize 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 (3585).

This viewpoint, premised upon the conception that blacks were incapable of mathematics and science education, ensured that few black students had access to quality mathematics and science instruction (Clegg, 1989). The inclusion of Mathematical Literacy as a compulsory alternative to mathematics in the new curriculum in the South African secondary school context as from 2006, will thus front an enormous test for teachers implementing the subject with regard to their extant beliefs of who can and should, and cannot and should not do mathematics, the urgency of which is similar to that called for by Robert Moses (2001:5):

> Today...the most urgent social issue affecting poor people and people of color is economic access. In today's world, economic access and full citizenship depend crucially on math and science literacy. I believe that the absence of math literacy in urban and rural communities throughout this country is an issue as urgent as the lack of Black voters in Mississippi was in 1961.

Notions of who should and should not do mathematics, are not unique to the South African context, and have been expressed in many reform documents[10] throughout the world. They have become 'encapsulated' in the 'hallmark slogan' advocated by the National Council of Teachers of mathematics, *mathematics for all* (Matthews, 2005). The emergence of this equity perspective in mathematics is however hindered by both objective and subjective realities.

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[10] See-an Agenda for School mathematics (1980), Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989), Standards for school mathematics (NCTM, 2000).

Meyer (1991) found that the limited success of such reform efforts was often linked to the design of such documents as they contained little detail to guide teachers in implementing them as intended. Moreover, negative expectations often resulted in negative mathematics outcomes (Cousins-Cooper, 2000; Kitchen, 2003; Strutchens, 2000; Weiss, 1994). The expectations that teachers possess for their pupils show a discrepancy along socio-economic standing and racial and cultural lines (Stiff, 2002). Qualities of the instructional milieu indicate social division and sanction and authenticate the deeds of specific groupings. As students navigate their path through this milieu, they grow to be highly conscious of their social limitations. In due course these students appear to believe and accept less of them and, in the end aspire too less (Bourdieu & Passeron, 1977). Accordingly, Mc Laughlin's (1990) maxim that 'belief can follow action' takes on an even richer significance, and as a consequence so does the assertion by Sutton & Krueger (2000) that "all students can learn mathematics, and they deserve the opportunity to do so" (1).

Supplementary cases in point showing the positive correlation between attitude, beliefs and successful implementation of curricula in mathematics and mathematical literacy are evident in the studies of, NCTM (2000), Askew (1997) and, Dosey *et al* (1998). They show that beliefs can and do effect actual student learning. That is pupils achieve better if their teacher believes that they can do better.

The question that arises then is succinctly framed by Matthews (2005:56), in discussing the constraints he has identified in the implementation of mathematics reforms, when he asks, "What is the resistance to equity ideology?" The answer to this may be linked to the high status of mathematics because of its socioeconomic utility, thus having the ability to serve political interests. Skovsmose and Valero (2001:44) write:

> We consider that mathematics education has the potential to contribute to the development of democratic forces in society. However, such potential is not linked intrinsically to the nature of mathematics and mathematics education. It emerges from a combination of factors such as whose engaged in mathematics practices, whose purposes they serve, which aims they pursue, when and where they occur, and why they are

> executed. As much as mathematics serves democratic interests, it has served antidemocratic ones.

In South Africa, in order to serve democratic interests, the new Mathematical Literacy curriculum, has been positioned as a subject intended for all. That is, a subject that the majority of pupils will have access to thereby entrenching their democratic right to mathematical literacy which is an essential component of any education system in the 21st century. However allowing for mathematical literacy on paper is not sufficient for its practical attainment. How the curriculum will be turned into reality in the classroom taking into consideration the multitude of contexts is only briefly addressed.

The implementation process of mathematics reform, that is the enactment in real time and context, is far more important for successful reform than are the politically laden curriculum dicta. Mathematics reform and educational change has thus consequences for social justice, equity, and democracy (Ball, 1994). For the reason that knowledge is closely associated to power, the two can be unified in the attainment of suppression (Foucault, 1983). What is a disturbing consequence of this overly political nature of the mathematics change process is that policy principles do not meet up to classroom realities (Kitchen, 2003; Rousseau & Powell, 2005) .It is one thing to argue and mandate that all pupils can and should do mathematics, but another to provide the necessary capacity equitably, in order to implement this successfully.

2.4 Linking the literature review to the conceptual framework: surface change

Surface changes are a common feature in classrooms where there is a lack of reform clarity. According to the Glenn Commission (2000), the actual learning experience in the United States is grounded in a basic teaching style that has remained essentially the same for two generations. The Commission described a typical mathematics class as one that begins with a review of previous material and homework, and then moves to a low-level problem illustration by the teacher. This is followed by supervised student work that imitates the teacher's procedures, and ends with a checking of solutions and the assignment of homework.

Research done by Taylor & Vinjevold (1999), amongst others confirms the findings of the Glenn Commission of the typical mathematics classroom. Together these matters of unchanged classrooms point to curriculum enactments that do not meet the intentions that the top-down prescriptions intend for implementing agents. What is required, is teaching practices that support, in all mathematics instruction, the ability and proclivity to make sense of the purpose of reform curricula and tackle implementation problems by serious exploration of teachers' own understanding and that of others. McLaughlin's (1990:13) states," you cannot mandate what matters".

Contemporary reform in mathematics urges deep changes in teaching and learning." Such learning would require substantial intellectual resources-ideas, images, materials, time-to provide opportunities to learn about mathematics, students and pedagogy" (Price & Ball, 1997:638). Cox (1975:9) recommends the art of entertaining ideas. He advise us "to invite [ideas] in and make them feel at home as you do company-while you get to know them". Getting to know ideas in this way is at the heart of learning. Yet issuing these invitations, staying in touch with the ideas, and exploring new aspects of them is easier said than done. Teachers differ with respect to their willingness to engage with new ideas. Indeed as individuals, teachers may find some ideas easy to invite in and others hard. To the extent that they keep an idea at the threshold, however, they limit their understanding of it, its complexity, and its potential.

For most South Africans, mathematical ideas are rarely invited in for a lengthy visit. Everyday experiences show little of the power and complexity of mathematical thinking in the teacher. It is common, given their school experience with mathematics, for teachers in this culture to experience mathematics as something to be remembered or told-procedures, rules, and facts that are given to teachers as ready-made. It is much less common for them to experience mathematics as something to be understood and created by their own work. It is an appreciation of such subtleties and the challenges they bring out that show how difficult it will be for South African teachers to learn and understand a new practice of mathematics instruction, that of Mathematical Literacy. In the end, "the disparities factor in curriculum reform is what teachers know, believe, and or willing to do" (Darling-Hammond, 1998: 650).

A foremost limitation to the scholarly work on mathematics reform implementation is that it has largely focused on the discipline of mathematics, which indicates that there is a scarcity of research on implementing agents of mathematical literacy. The literature on teacher understanding of ML curricula, and the impact of teaching ML on mathematics teachers identities is mostly limited in the former to first world countries and, in the later, is scarce and restricted to all encompassing mathematics curricula.

As this is a new curriculum and discipline in South Africa, there is no empirical evidence on how and why teachers implement ML .It is this 'gap' in the research literature, namely, how teachers understand and implement a mathematics curriculum distinctly different from the traditional curriculum, that my study is focused on.

In the context of ML implementation, this research may expose some key features that encumber or advance instructional changes in emerging democracies. Such empirical evidence could significantly provide for emerging explanations for ML reform change.

2.5 Summary of Chapter Two

Chapter two explored the literature on curriculum implementation in both mathematics and mathematical literacy. What is evidenced is that instructional practice in classrooms and especially mathematics classrooms remains unchanged despite the willingness of teachers to embrace reform change. Numerous theories some based in empirical evidence and others not, were offered as explanations with the argument converging that in the face of progressive mathematics reforms, a broader perspective of understanding implementation in ML is required.

The next chapter provides for a conceptual framework that allows an analytic lens for the paradox of 'theory and enaction'.

CHAPTER 3

A 'Deep Change' framework for understanding reforms in mathematics education

"Nothing endures, but change"
Heraclitus (540-480BC)

3.1 Introduction

In this study I draw on Michael Fullan's theory of deep change as a conceptual framework through which I explore and explain the (in) consistencies in the implementation process of a mathematics curriculum.

Incessant change is a state of the post-modern era (Harvey, 1989). Change is not at all times smooth, nor does it progress in a predictable path (Cohen, 1994). Furthermore the contexts in which present-day teachers work is multifaceted, and is also characterised by paradox (Hargreaves, 1994). Undeniably, teachers observe their work to be incessantly affected by obligatory curricular change (Clandinin&Connelly, 1995). Interestingly however, is that the changes required by reforms are often not apparent in the classrooms, with practices continuing as predictable as ever. And, "even when students find the materials and terms of mathematics changed, the changes often appear little more than cosmetic" (Price & Ball, 1997:637).

Price & Ball (1997:661) further reason that making change in mathematics presents unusual challenges for reasons including, that "mathematics reforms are far from a blueprint of action, a plan to be implemented" and secondly mathematics teachers "formal education is typically thin, and they often do not feel mathematically competent or confident". As a result of this, surface change in mathematics classrooms is a common feature. Schools use the reform labels but do not ensue a good number of the practices advocated (Romberg, 1985).

Cohen & Hill (2000) found teachers behavior below the surface to be ingrained in conventional teaching styles. Such findings are consistent with those of Weiss *et al* (1996), Haug (1999) and Cuban (1984). Larry Cuban wrote that reforms are like storms on the surface of a deep ocean; they churn the surface but have a modest impression on developments further under. This is routinely the case, for the reasons that, implementing agents rely markedly on superficial resemblances amid their current practice and the reform ideas, and so the innovative aspects of the reform are eluded (Spilanne *et al*, 2002).

Additionally, it also results when 'memory is a substitute for thinking' (Pfeffer & Sutton, 2000). That is, teachers use memory as a substitute for thinking and continue to often do what they did in the past with little or no reflection about the deep ideas required by new reforms. What is more is that curriculum documents can mean different things to different people. "Indeed, practitioners often develop a superficial understanding of the reform, viewing the reform idea as a set of specific practices" (Spillane *et al*, 2002:416). Such misinterpretations of a curriculum are often based on beliefs and practices that are part of individual teachers' prior knowledge base.

Change may also be incremental. It can start with small changes in the state of the classroom, which over a period of time; grow to encompass the transformative process of reform. Such incremental change Spillane *et al* (2002:415) note, occurs "when little or no alteration of the extant purposes and expectations of the people undertaking the change" is required. Such change may be useful for new curricula that do not differ significantly from those of the past.

For example the requirement to teach certain content in an earlier grade will not require fundamental changes in the teachers' understandings, beliefs and teaching methodology, only in their planning. However incremental change does not allow for reforms that require deep-seated paradigm shifts in both teaching and learning. In mathematics reforms such requirements are commonplace in new curricula.

Deep change, Quinn (1996:3, 9) argues,

> …differs from incremental change in that it requires new ways of thinking and behaving. It is change that is major in scope, discontinuous with the past and generally irreversible. The deep change effort distorts existing patterns of action and involves taking risks. Deep change means surrendering control...Deep change can occur at both the organizational and the personal level. Insights into one level help us to understand the other better.

This view of deep change holds for the dismantling of the status quo. It requires the deconstruction of views and beliefs and an abandonment of the past and a start from the very beginning. In so doing, it requires discipline, courage and motivation, which is at the core of changing ourselves (*ibid*). But because this is a radical change people would rather experience the pain of 'slow death' then the threat of changing. Quinn (1996:200) continues:

> The term *radical* is derived from the Latin word for "root". In mathematics, for example, we use the radical sign to indicate the square root. To make radical change, one must move to the root, the origin or archetype. An influential vision reflects the insight of an individual group that has deeply contemplated the core issues.

Less overstated definitions for deep change are provided by Fullan (1991, 1993, 2004, 2005) and Coburn (2003). Fullan (1991) explains deep change as one concerning the construction of sophisticated meaning of the change process required by a new curriculum. Sophisticated meaning can only be arrived at when a fundamental change in the way that teachers think occurs. Fullan (1995:23) explains this as follows:

> It is no denial of the potential worth of particular innovations to observe that unless deep change in thinking skills occurs there will be a limited impact... [The] main problem in education is not the resistance to change, but the presence of too many innovations adopted uncritically and superficially and on an ad hoc fragmented basis

By this he means, changing core assumptions and beliefs with regard to both teaching and learning. Coburn's (1993:4) definition for deep change echoes with the thoughts of Fullan, he explains:

> By 'deep change' I mean change that goes beyond the surface structures or procedures (such as changes in materials, classroom organizations, or the addition of specific activities) to alter teacher's beliefs, norms of social interaction and pedagogical principles as enacted in the curriculum.

On which end of the deep change continuum a reform is positioned, is dependent on both the individual implementing the reform and on the school. That is, depending on existing classroom practices, some teachers will require radical change in order to attain the intentions of a reform, whereas for others going deeper may require less fundamental changes. The paradigm shifts made by both sets of teachers is as such a product of their existing beliefs and practices. Which concept, of deep change than works best, is dependent on the individual in the context of the classroom, with no definition having supremacy over the other.

Deep-change incorporates the notion of collaboration, which necessitates the development of professional communities and in turn the 'reculturing' of classrooms and schools. Fullan (2005a: 3) explains the difference that this makes:

> What does make a difference is reculturing the process of developing professional learning communities in the school. Reculturing involves going from a situation of limited attention to assessment and pedagogy to a situation in which teachers and others routinely focus on these matters and make associated improvements. Structures can block or facilitate this process, but the development of a professional community must become the key driver of improvement. When this happens, deeper changes in both culture and structure can be accomplished.

Forging partnerships within a school and between schools is important in educational change, for it allows for reflection and discussion of common and unique difficulties and strengths. In turn these allow for a deeper exploration of the curriculum, and thus more informed action. This leads to a clearer implementation pathway more congruent with the intended reform process. Fullan & Hargreaves (1992) found that collaboration between teacher's accords openings for access to new ideas and knowledge, which can make available motivations for improved instructional teaching and can be a factor to improvement in student performance. This is because "deep pedagogy and deep learning cultures feed on each other" (Fullan, 2004:12). And in so doing facilitate the constant improvement that is obligatory in 'raising the bar' and 'closing the gap' of student learning and achievement (Fullan, 2005d: 1).

This is not to say that individualism is bad, but that by collaboration deeper meanings of a curriculum can be arrived at in a more objective way. Individuals may believe that the changes they have made are deep, but these measures in an isolated context are subjective. That is, individuals who work in isolation have only their old teaching to compare with their new teaching and may find, using their own subjective yardsticks, that they have made radical changes when in effect they have made little progress in the direction of the new reform The starting point for change for one teacher may be the end point of another whose starting point was far more traditional. Such comparisons and analyses can only be made in professional communities implementing a new reform. Indeed connecting schools and teachers with common denominators not only builds capacity but also can attribute to the avoidance of alienation and fear, which often constrain the reform process.

Collaboration, however, is not without problems, for it may lead to conflict as a result of professional competitiveness. This conflict can be minimized by introducing what Fullan *et al* (2004) label ‘nonnegotiables’. These include, raising the bar and closing the gap, promoting ongoing development of professional capacity, and ensuring transparency of results. These "reduce the areas of conflict and channel differences into areas that are essential for problem solving" (Fullan *et al,* 2004:5). It must also be noted that conflict is not always negative, for it may lead to creativity. But conflict that is negative and seeks to undermine the collective purpose is the conflict that needs addressing by introducing 'nonnegotiables'.

Besides collaboration then a 'collective moral purpose' is also a requirement for deep change. "The moral imperative means that everyone has a responsibility for changing the larger education context for the better" (Fullan *et al*, 2004:2). Moral purpose, achieves an even higher significance, when the reform addresses equity issues, such as a mathematics curriculum intended for all. That is because, such reform can only be successful if all stakeholders, particularly implementing agents, share the same vision of the importance of implementing such a reform as intended, not only within their classroom but in the classrooms of the community and also the whole. For, a collective moral purpose makes explicit the goal of 'raising the bar and closing the gap' with respect to "numeracy, which is on the agenda of many countries whose performance, is unacceptably low" (Fullan, 2005b: 4).

Deep ownership of a curriculum is also suggested by this framework as a means to acquiring "deeper and wider reform in pedagogy and other aspects of the curriculum" (Fullan, 2004:4). Ownership entails not only a deep understanding and familiarity with a curriculum but also a favorable acceptance of the curriculum by the teacher. Owning a curriculum implies that the teacher believes in the new curriculum and hence the reform. It needs to be realized on the 'micro-scale', that is by the teacher and, in large-scale systemic reform that ownership must be shared. Such ownership according to Fullan (2004:5) needs to meet two main criteria:

- it must mobilize the ingenuity and creative resources of a critical mass of the whole system
- it must foster a ‘we-we' or collective commitment and identity with the system as a whole, and its transformation.

That is, communication with others and a shared commitment deepens the process of reform and enables implementation of a curriculum that is held by implementing agents to be that of their 'own' - something they understand and believe in. This both contributes towards and enables better teaching and thus learning.

Deep learning is a necessity for deep change. And because deep change takes time, so does deep learning. It cannot be acquired simply by reading a curriculum document. It has to take place during the process of change (Angelo, 1999). As teachers are faced with obstacles in the classroom context, reflection and discussion about the curriculum and its purpose as well as the content and pedagogy it espouses allows for the deep learning that provides the clarity needed by new reforms. Deep learning is not only about working smarter and harder but also about accruing resources that enable one to go deeper and further (Fullan, 2005b). Indeed, going deeper and further requires a lot of time and energy, which often cannot be maintained over a long period of time. However, if resources have been accumulated and collaborative networks established, which can be used to collectively problem solve, the energy and time needed to sustain the reform may be less than that needed at the beginning of the implementation process. Long-term sustainability then becomes easier to accomplish (Fullan, 2005c).

3.2 Why deep change is important in mathematics reforms

Contemporary reforms in mathematics and numeracy urge for deep changes in both teaching and learning (Price & Ball, 1997). For the magnitude of the changes envisioned by these reforms suggests a need for both a deep understanding of the curriculum and the implementation process. What is more is that the deep change required by some mathematics reforms is radical, as it requires a change in identity in relation to mathematics. Ross (2004:592) writes:

> Many reformers contend that changes in teachers' beliefs, habits, and attitudes toward mathematics will improve mathematics education. However, <u>identity</u> in relation to mathematics is constructed over long periods of time, through many experiences. To change an individual's system of knowledge (which amounts to a change in identity) is an intense and personal endeavor (*emphasis added*).

The deep change framework that allows for changing the past and learning entirely new ways of teaching supports such change in identity. In South Africa, for example, where the teaching of mathematics has been limited to a few, the introduction of Mathematical

Literacy for all learners in the curriculum, will require fundamental changes. Teachers will have to rethink their mathematics identity with respect to who can and cannot do mathematics, which should and should not teach mathematical literacy, and also further find ways to change their instructional practices in terms of pedagogy distinctly different from the way in which they were taught. The traditional approach to teaching and learning Mathematics in South African schools aimed to achieve levels of abstraction that did not develop students' skills in mathematical literacy, in which mathematics must be taught in and through a 'real-life' context. An understanding of the nature of mathematical literacy will also be required if this new subject is to be implemented as such and not merely as a 'watered-down' version of the mathematics curriculum.

This is necessitated in order to gain ownership of the Mathematical Literacy curriculum, and in so doing ensure successful implementation. Lacking deep mathematical literacy themselves however, the grappling of the new ideas will be a difficult process for it may require what Spillane *et al* (2002:417) describe as "deep conceptual change, in which teachers rethink an entire system of interacting attitudes, beliefs, and practices". Such fundamental changes are not easy, especially when the majority of teachers find themselves at the receiving end of such a major challenge. Papert (1993:17) notes:

> ...deep systemic change has never come easy [there is a] stubborn refusal to abandon the old ways... [when there is a] challenge to long-established procedures. The problem in education has an additional element. Most honest Schoolers are locked in the assumption that School's way is the only way because they have never seen or imagined convincing alternatives in the ability to impact certain kinds of knowledge.

Seeing the alternative though is not the same as knowing how to achieve it, for the actual steps for the achievement may not be known (Quinn, 1996). If teachers accept this, they can better muster the strength, obligation, energy, and time it will entail to bring about the deep transformative change that, for example, Mathematical Literacy requires. The deep change framework provides several such steps that can afford teachers with methods they can use to get to the nucleus of a new reform curriculum.

3.3 Limitations of deep change in mathematics reforms

The assumption made in a deep change framework is that if deep change is recognized as a necessity for a reform, its attainment will follow suit. However, because deep change takes a long time, teachers may find that the energy and time required in making the change is not worth their while investing in due to personal motivations. Sergiovanni (1998:585) in his discussion of 'theories of human nature' describes this as the 'constrained view', that is, "it is believed that teachers will act selfishly if given the chance", for their "primary concern is to maximize self-interest". This is a very real concern particularly in developing countries where teachers face 'burn-out' as a result of continuous change in the face of adverse teaching environments. For this reason incentives and sanctions become important in circumventing this constriction (*ibid*.).

What is more is that deep change cannot be mandated. Curriculum planners may recognize it as a necessary condition but it is the teachers who need to accept it if implementation is to occur as intended. Hill (1997) suggests that before accepting that change is necessary, teachers must believe it is worthwhile to put time and effort into learning new ideas, be able to understand them, and be aware of and dissatisfied with their current practices. Such an awareness is in it self intricate, for even though teachers may not be satisfied with current mathematics curricula changing the status quo will be abandoning content and pedagogy that has come to be part of their identity as to who they are as mathematics teachers. Changing this identity can result in anxiety and confusion, therefore making it easier for them to simply implement the reforms superficially in order to avoid sanctions, rather then delving deep into them.

In addition, "if teachers build on past practices as they change, then their view of how much they have accomplished will depend on where they start"(Cohen, 1990:325). Teachers may believe that they have undergone deep change, as they find that their classroom practices are very different to what they use to be, when in reality the intentions of the reform are not being met to the required degree. This subjectivity in performance can also be part of a professional teaching community whose collective starting point, before the reform, were very traditional classroom practices. How and why to move beyond the plateau of the changes already made becomes a stumbling block for reform efforts.

This framework is further a compliance one. In essence it judges the performance of teachers against predefined behaviours as expressed in the curriculum and the related official documents. The objective pursued then becomes a consideration between the displayed actions of teachers and the anticipated actions with the assumption that this discrepancy be sufficiently narrow to indicate a deep understanding.

Finally, how does one go about 'validating' deep change, when deep change requires time to be accomplished? An idea may be used in a classroom that over a period of time will evolve into change that is deep, but at the outset the evidence may be lacking or limited. Using benchmarks that are not subjectively determined to gage teacher progress may be offered as a solution but depending on the context they may require a longer period of time to be achieved, and so falsely show a result of no or superficial change when in effect the deep change is still to come. In South Africa, the only benchmark, to date, for the implementation of the compulsory Mathematical Literacy curriculum in Grade 10 in 2006, is the proposed exemplar of an assessment paper that is to be sent to schools during the first year. How this is to validate the deep changes that this new reform requires remains to be seen. An example such as this provides evidence on why empirical research in mathematics reform using the deep change framework is essential, particularly in developing countries.

3.4 Using the deep change framework in my research

The deep change theory will be explored as it applies to the implementation of Mathematical Literacy in South Africa through the following three propositions.

Proposition one

Teachers may not have a deep understanding of the purposes, problems and possibilities contained in the Mathematical Literacy curriculum

My proposition is that teachers may not have the deep understanding that the implementation of mathematical literacy requires, but rather a superficial grasp of the new curriculum. Several authors support this proposition in that they have found that amongst the changes that take place in the classrooms few can be considered deep; due to a lack of deep understanding of the reform by the teacher (see Darling-Hammond, 1998; Elmore, 1996; Fullan, 2001). Darling-Hammond (1998:650) notes:

> The flawed belief that reforms can be "replicated" elsewhere once they have been developed in demonstration sites is one key to the unhappy history of curriculum change. The process of change is inherently constructivist. Any reform that is merely implemented will eventually recede rather than taking root. Each school community must struggle with new ideas for itself if it is to develop the deep understanding and commitment needed to engage in the continual problem solving demanded by major changes in practice.

Proposition two

Teachers implement the Mathematical Literacy curriculum in their classroom through the medium of beliefs and pedagogies that are already entrenched in their practice

Teachers will implement the Mathematical Literacy curriculum as a 'watered-down' version of the more abstract Mathematics curriculum. Or, they will implement it by means of the same methods, with few if any adjustments, they used for the previous Standard Grade Mathematics curriculum. This is because, the extant knowledge they bring to the new reform will prevent them from abandoning their old ways and learning and using new ones. Sergiovanni (1998:577) supports this assertion, he observes:

> Changing a culture requires that people, both individually and collectively, move from something familiar and important into an empty space. And then once they are in this empty space, to build a new set of norms, a new cultural order to fill it up. Deep change, in other words, requires the reconstructing of existing individual and collective mindscapes of practice.

Proposition three

Teachers implement mathematical literacy, as an alternative to mathematics, only because it is a mandatory subject, and in so doing avoid sanctions

I claim that teachers will implement mathematical literacy because they have to, and not because the have a deep belief that numeracy is essential for democratic citizenship. In other words, the curriculum will be taught to the 'weaker' mathematics students in order to avoid sanctions. It will not be introduced in a manner that is true to its' 'spirit'. That is as a means for pupils to begin to make sense of the world of numbers that surrounds them and their communities daily, and in so doing promote human resource development and democratic citizenship.

3.5 Synthesis

In Chapter Three I expand the conceptual framework of deep change to include the discipline of Mathematical Literacy, in order to provide for a theoretical tool through which the union between curriculum and implementation can be appraised. The deep change framework explicated provides for the inclusion of different increments of required change and the chapter further discusses both the strengths and limitations of such a theoretical framework. In this chapter I also state three propositions framed in 'deep change' conceptual theory, with regards to teacher understanding and implementation which will be tested later in the study, through an analysis of the data collected.

The research design that was engaged in for this study is the topic of the next chapter.

CHAPTER 4

The Research Process:
Inquiry, Design & Methods

4.1 Introduction & Design

This chapter provides a description of, and justification for, the research methods used that framed the collection of data for this study. It describes the carefully selected design; the sampling method used, and provides a detailed account of how the evidentiary base was established. It also presents the details of how the concerns of reliability and validity were addressed.

The primary goal of this study was to explore how and why teachers implement the new Mathematical Literacy curriculum in their classroom, and to explain how their understanding of this curriculum influences their classroom enactment. To realize this goal, I chose qualitative methods using an explorative case study design governed by Cohen, Manion and Morrison's (2000) notion of 'fitness for purpose'. This is because as Yin (2003:1) says," case studies are the preferred strategy when 'how' or 'why' questions are being posed". Furthermore, qualitative case studies seek out meaning and understanding of a bounded system, support inductive investigative strategies, and generate a richly descriptive end product (Merriam, 1998). These qualities of qualitative case studies were congruent with the purposes of this research.

The case study inquiry was also found to fit this research as a situation presented itself in which it was expected that emergent variables of interest would not only be more than those on the data points, but also perhaps different. As a case study relies on multiple sources of evidence and benefits from the prior development of theoretical propositions (Yin, 2003), something that was required to focus the purpose of this explorative study, this method was the 'best-fit' for my purposes.

In addition, qualitative inquiry allows the researcher, as the primary instrument of data collection, direct entrée to the experiences of the participants, in this case the teachers (Bogdan & Biklen, 1982). And as Bascia & Hargreaves (2000) explain, the best way to examine the subjective experiences and thinking of teachers is through an in-depth, contextually founded interpretative design.

Human behavior is fluid, dynamic and contextual. It follows that if a goal of this study were to deepen our understanding, through exploration of the complexity of curriculum enactment in context, a qualitative case study would provide the 'wide-angle' lens required for this purpose. Cohen *et al* (2000:181) concur with this position: "contexts are unique and dynamic, and hence case studies investigate and report the complex dynamic and unfolding interactions of events." Hence, a case study method would capture this dynamism by retaining "the holistic and meaningful characteristics of real-life events" (Yin, 2003:2). Indeed, qualitative research in an exploratory vein allows for rich and thick descriptions of new phenomena that capture the 'essence' of the real classroom practice; such details cannot simply be captured by quantitative studies, with their positivist view, that reduce phenomena to pre-determined variables.

Furthermore, as the purpose of this research entails describing and analyzing the understanding and enactment of a curriculum, my own experiences with curriculum change for over sixteen years guided me in supporting Doll's (1993) raison d'être that the objectivity of positivism symbolizes a closed system of planning and practice that sits uncomfortably with the notion of education as an opening process that sees curricula as being rich and relational. Lastly, as Schramm (1971) observes, the essence of a case study, the central tendency among all types of case study, is that it tries to illuminate a decision or set of decisions: why they were taken, how they were *implemented*, and with what results (in Yin, 2003:12, emphasis added).

As a preface to the case studies a snapshot survey dealing with the research questions and propositions of this study, was also included in the research design. The survey is an informal one, and does not use sophisticated techniques to present relational analysis. It is primarily used to present the beliefs and attitudes of a multitude of educators who, like the respondents in the case studies, were undertaking the implementation of a new mathematical literacy curriculum in its very first year. Its attraction for inclusion in this exploratory study is that it represents attitudes and beliefs of 'a wide target population' as well as providing for emerging themes and information (Morrison, 1993).

The survey was not used as the primary method, for as previously mentioned the main research rationale was to capture how mathematical literacy was unfolding in actual classroom practice, a purpose that required deep and rich descriptions of the complexity of the intertwined spheres of social and personal. That is not to say that the findings of the survey are insignificant but only that they enhance those of the case studies and the research study as a whole as embedded units of analysis.

4.2 Qualitative concerns

Problems encountered with using a case study methodology include the concern of 'lack of rigor' (Yin, 2003). This is addressed in this study through the following of a systematic approach both in the design of data collection instruments and in the analysis of generated data. An additional problem which is the main prejudice for a qualitative case study is that generalisability "looms larger here than with other types of qualitative research" (Merriam, 2002:179). However, if the intention is not to find generalisable explanations but to provide rich, vivid and deep descriptions of the effects curriculum understanding has on implementation the case study method is 'fit for its purpose'. In addition, the findings "are generalizable to theoretical propositions" even though they are "not to populations or universes" (Yin, 2003:10).

What is the value then, of such exploratory research? The answer to this is twofold. Firstly exploratory case studies can act as pilots that generate hypotheses that can be explored and tested further by other researchers (Cohen *et al*, 2000). As this study was conducted within six months of the implementation date of the Mathematical Literacy curriculum, it can serve to provide through a richly descriptive narrative a window of evidence for further research and study. Secondly, this study is not only a means to an end but an end in itself. This is because the study is significant in its own right, for it has generated tentative explanations and interpretations of the poorly understood phenomenon of implementing mandatory mathematical literacy curricula in secondary schools in developing countries, the findings of which may elicit broader implications for curriculum design and curriculum implementation.

4.3 Sampling

As the Mathematical Literacy curriculum was in its inception year at the time of the study, the design was limited to include only Grade Ten teachers, as they were the only ones teaching the new Mathematical Literacy curriculum. Having decided on two in-depth case studies, a number chosen to ensure far-reaching and deep observation and analysis, I proceeded by contacting schools and asking if they offered Mathematical Literacy. Having ensured the participation of two such schools early on in the year I was set to begin the study in the latter part of the month of July 2006.The intention was to observe five weeks of lessons at each school and a follow up week in October.

4.3.1 Reality Strikes

On arriving at the first school to begin with the fieldwork I found that gaining access to schools was not as easy as initially thought. I had sat up a meeting with the Principal of school number one after a lengthy telephonic conversation, during which he had agreed to allow me access to his school. During the first day of fieldwork I was to meet with the Principal to explain in person the purpose of the study and to speak with the members of his mathematics department in order to ascertain if any were willing and interested in participating. The Principal was enthusiastic and called for the Head of the Mathematics Department so that I could explain the research to her. He then left the meeting to join the rest of the staff for tea, as it was break. During the conversation with the Head of Department I was informed that this school did not offer Mathematical Literacy. She informed me that the decision had been taken by the Principal as he believed that being a

Technical School their pupils did not proceed with tertiary studies in commerce, and as this curriculum favored such degrees, he had chosen not to offer the subject. She was as confused as I was, as to why the Principal had stated that they did offer Mathematical Literacy.

The second school that I thought I had secured was an independent private school in a leafy suburb of Johannesburg. Research at this site did not materialize for the educator that had agreed to partake in the study resigned three weeks before the fieldwork was to commence, as she felt that the amount of work at the school was beyond what as a mother of a three year old child she was willing or capable of doing. She left the High School and found a post near her home as a Primary School teacher, which she believed, would require less work after hours. The High School that she left in the meantime was struggling to find a teacher that was willing to teach Mathematical Literacy, the classes of which had temporarily been assigned to the other members of the mathematics department. As these educators had not been teaching the curriculum from the beginning of the year it would not have suited the purpose of this study to use them as participants even though two of them were willing.

These disruptions to the commencement of the fieldwork also presented me, the researcher, with technicalities that needed resolution. The documentation I had completed and sent off to the Education Department to apply for permission to conduct the study were now null and void, for the schools indicated were no longer research sites. The forms were then again completed and send off for a second time with the two schools in which I finally did manage to secure permission and access to conduct the research.

4.3.2 Finally: Participants

4.3.2.1 Willing Case Study Respondents

The third attempt at finding not only a willing participant but also leadership that would allow for research to be conducted proved more fruitful. I sat up a meeting at East Rand

High School as it was mentioned to me by a colleague that they were offering mathematical literacy, and had more than one teacher teaching the subject. This school was situated on the East Rand approximately forty-five kilometers east from Johannesburg's city center. The willing respondent from this school was a qualified Mathematics teacher with seventeen years of teaching experience in Mathematics.

The second respondent, Michael Michaels[11], I met at a Mathematical Literacy workshop, which we had both attended earlier on that year. At the time I had thought that I had secured the two sites for the research and did not think of asking him to participate. After having failed on the first two attempts, I contacted Michael and explained the research to him. Shortly thereafter I not only had a second participant but also a willing principal. The research at Michael's school also presented a problem however, in that the initial design of observing Michael's lessons for six weeks were reduced to five as Michael fell ill and the research in the follow up week in October never took place.

4.3.2.2 Informal Snap Shot Survey

Cohen *et.al.* (2000:380) see research in education as including the following modern and postmodern approaches:

> [The] mixed pedigree of emerging development signals that educational research is eclectic in its paradigms, traditions, methodologies, instrumentation and data analysis. Further, it is important to recognize that educational research is integrative; it steps over the traditional boundaries of different disciplines; its epistemological basis being, in part, derivative, and suggestive of a need to cross such boundaries and protected territories...Just as new knowledge crosses traditional epistemological boundaries, is at the frontiers of traditional disciplines and creates new ones, so research, in its endeavor to create new knowledge, need not be hidden by tradition.

Concurring with this, I proceeded to integrate into this explorative study the acquisition of evidence from two other sources, namely informal conversations and an Internet forum

[11] This pseudonym will be used for the second participant and Norman Mhuka for the first, in order to respect their wish of anonymity.

that was set up by one teacher for questions and answers pertaining to the new core mathematics and the mathematical literacy curricula. These findings, as already mentioned, formed part of the embedded unit of analysis.

4.3.2.2.1 Conversation Participants

Over a fourteen-month period I spoke to and interviewed fifty-four Mathematical Literacy educators. As a Mathematics educator I found myself at workshops, conferences and meetings at which educators teaching Mathematical Literacy were also present and even though the conversations were informal I made it clear that the line of inquiry was establishing an embedded evidence base for my study. The informal setting I found to be very conducive to honesty and comfort, and many of these educators shared freely their experiences with this new curriculum to date.

4.3.2.2.2 On-Line Users

A forum on the Internet had been set up to allow for discussion on how the new FET Mathematics was being implemented in the classroom. This was soon also used for Mathematical Literacy and revelations from the dialogue that appeared on this forum, over a six-month period, and pertained to the purpose of this study as exploratory, was also further captured.

4.3.3 Initial Design

Initially the design used for this study in my defense of the research proposal included the use of 'purposive sampling'. This I was to use to select the two teachers that would primarily form the units of analysis of this study. The criteria that I thought I would be able to use included, experience, qualifications and community standing. That is, the two teachers that I had wanted to be part of the study should be educators that were highly experienced, innovative and thought of as good mathematics educators by the pupils of the school and by the community at large. This sampling technique I argued would allow me access to individuals, who any reasonable person would assume, would have the ability and 'know-how' to implement the Mathematical Literacy curriculum as intended. In doing this, I could focus on the nuance variable of deep understanding, that I wished to explore, and not on the content knowledge, qualifications and years of experience, with respect to classroom enactment. The reality did not unfold as expected. However the one participant, namely Michael Michaels, did to a degree fit this design of purposive sampling as I finally decided to include him not because I was running out of options but because of the way that I found he conducted himself at the workshop. His conduct suggested a deep engagement with the material dealt with at the workshop and also an approach from the other workshop participants that spoke of respect and admiration.

Ultimately the inclusion of the two respondents was based on that they were Grade 10 mathematical literacy teachers, were qualified and experienced mathematics teachers having taught secondary school mathematics, each for over fifteen years, and were well known and regarded amongst their peers and principals.

4.3.4 Sample Size

I recognize that even though two teachers allow for intensive case research, they by no means represent a significant statistical sample. But they should provide for the deep insights required by the purpose of this study As Cohen *et al* (2000:93) note, "size depends on the purpose (and style) of the study". Furthermore if the "findings support the propositions, the results may represent a strong start toward theoretical replication" (Yin, 2003:47). Two teachers is also a manageable sample for one researcher and provide an adequate opportunity to access in-depth qualitative information. Exploring the previously uncharted area of Mathematical Literacy implementation in South Africa through two teachers, over a five week period in late July and August with a follow up week in October, should bring to light the difficulties and experiences these teachers are having with the implementation process of this new curriculum.

4.4 Data Collection

I used various methods to collect data so that methodological triangulation would be possible. This is because the inclusion of multiple sources of evidence allowed for the development of converging lines of inquiry that could be used to corroborate findings (Yin, 2003). If, on the other hand, these lines had been found to diverge alternative explanations would have had to be formulated. Taken together, these lines as a product of the various sources of data collection, elicited a reliable and valid method of acquiring information.

The data collected for the two case studies was done by means of interviews, observations, and documents, which are the three main sources of data for qualitative research (Merriam, 2002). These three sources were supplemented with additional sources, which included a questionnaire and a researcher's journal, all of which are attached in the Appendix.

Before the fieldwork commenced the data collection instruments were first pilot tested on a colleague teaching the Mathematical Literacy curriculum at a neighboring private community school. During this phase, which included one week of comprehensive interviews, discussion and three classroom observations the data collection instruments were refined and further brought into line with the research questions. This week of pilot testing was invaluable to finalizing the design of the data collection phase of the case studies as I found the following words of Yin (2003:79) to ring true:

> It is important to note that a pilot test is not a pretest. The pilot case is more formative, assisting you to develop relevant lines of questions-possibly even providing some conceptual clarification for the research design as well.

4.4.1 Classroom observations

The classroom observations were of a non-participant nature using a semi-structured observation schedule, which was drawn up to test and explore the propositions of this study. A semi-structured design was used for even though the research questions and propositions directed what was to be studied a more structured observation schedule would have precluded the capturing of what Cohen *et al* (2000) refer to as 'critical incidents'. Such incidents may be 'non-routine but very revealing' as they may offer insights that may not have been evidenced by a structured questionnaire (ibid.). These observations were conducted in order to provide evidence for validation or rebuttal of the two educators own descriptions of their classroom practice, as well as to enhance the narrative by capturing the details of the actual context. Looking at what takes place *in situ* rather than at second hand is thus the more desirable option (Patton, 1990).

In the case of the first respondent, namely Norman Mhuka I observed nineteen one-hour lessons over a period of five continuous weeks and one follow up week two months later. The second respondent's instructional practice I observed over a five-week period and the observation time totaled twenty-one hours. The follow up week, which formed part of the initial design, was not conducted for as mentioned earlier, Michael fell ill and was absent from FET High School for eleven days. My notes also included personal reflections of the observations made.

4.4.2 Questionnaires

The questionnaires were also of a semi-structured nature. The closed ended questions were directed at acquiring the necessary background knowledge of the teachers and that of the context they found themselves working in. The inclusion of the more open-ended questions was used to elicit their understandings of the curriculum and its implementation process. The questionnaires were issued to the two respondents on the very first day of the fieldwork. Norman returned his four weeks later, Michael two days after issue. Norman indicated that his wife had helped him in answering some of the open-ended questions. This posed a concern in terms of reliability and validity, however as it was not the only source of data collection, triangulation with the other data points was used to minimize the impact on said reliability.

4.4.3 Interviews

The interviews conducted with the two respondents were used to pursue the research questions in a flexible manner as well as acquiring further biographical information that pertained both to the purpose of the study and the rich-descriptive write up of the two cases. The interview schedules were semi-structured and as such allowed scope and exploration through the use of open-ended questions. Additionally the open-ended questions allowed for flexibility during the interview, in terms of pursuing responses that were relevant, different or unexpected. Cohen *et al* (2000:255) argue for the difference that such questions can make:" it is the open-ended responses that might contain the 'gems' of information that might not be caught up in the questionnaires" as they "can catch the authenticity, richness, depth of response, honesty and candor which are the hallmarks of qualitative data".

The interviews were conducted pre- classroom observation and post-lesson. The post-lesson interviews avoided loaded questions in order to minimize what Lampert (1986) described as "post-hoc rationalization”. Questions that inferred my feelings and understandings of what I was observing were avoided and as such allowed for more truthful responses from the teachers in why they were doing and feeling as they did. Initially my intention was to audiotape these lengthy interviews but after the first interview with the first respondent I found that the recorder became a focus point for him. After the first interview the recorder was not used again, and I recorded all replies manually and verbatim. Collectively, the interviews amounted to thirty-three hours of units of time.

4.4.4 Documents

Documentation was also collected for subsequent analysis. The documents I looked at were the Mathematical Literacy curriculum, the related Assessment Guidelines, the Learning Programme Guidelines and the Teachers Handbook for mathematical literacy. Minutes of departmental staff meetings, subject files and learner materials were also further analyzed. I requested documentation with regards to policies and vision statements that the schools may have had with respect to implementing the FET and in particular mathematical literacy, these did not exist at either of the two case study sites. The school and staff timetables and any documentation pertaining to staff development in the mathematics department were additionally perused.

The strength of using documentation as a data collection tool is not only that it further enabled triangulation through corroboration and augmentation (Yin, 2003) but also that the above said documents were independent of the "whims of human beings whose cooperation was essential for collecting data through interviews and observations" (Merriam, 2002:12). Having stated that however, it is important to acknowledge that teacher cooperation was still essential in acquiring the documents, but less so in the analysis of the data contained therein.

As a final instrument, a **researcher's journal** was also kept in order to further enhance the data collection. I used it to reflect upon my daily observations, noting new ideas, difficulties, mistakes, confusions and breakthroughs that I had made. The journal also enabled me to identify my extant and emerging subjectivities and in so doing monitored them so as to reduce subjectivity in the analysis process.

The nature of the data collected was words, images and categories, which were sorted, coded and stored by a systematic recording method. Three databases were set up on computer, one for each case study, and one for the data that was included in the informal survey.

4.5 Reliability and Validity

To ensure reliability, that is consistency and dependability, I used the four strategies as suggested by Merriam (2002). Triangulation, peer examinations, 'audit-trails', and the keeping of a researcher's journal. Reliability is indispensable, for validity presupposes reliability. The validity that was pursued was more in keeping with Lincoln and Guba's (1985) notion of 'trustworthiness' that replaces the more conventional views on validity as it encompasses issues of credibility, confirmability, transferability and dependability (Cohen, *et al*: 2000).

Trustworthiness was constructed through a factual and truthful report of what the study had revealed, through the analysis of the various sources of evidence, irrespective of whether the findings validated the propositions made. A chain of evidence was constructed to allow for the 'evidentiary process' to be traced by any interested party who in future wishes to validate, refute, or construct alternative meanings for the findings (Yin, 2003). Furthermore the draft report was given to key informants in order to be reviewed. External validity was not a priority as generalizing the data was not an objective of this exploratory study, but rather that of acquiring a good in-depth account of the cases in the context in which they were situated. Lincoln & Guba (1985:316) concur with this when they note that "it is not the [qualitative] researcher's task to provide an index for transferability; rather, researchers should provide sufficiently rich data for the readers and users of research to determine whether transferability is possible".

Threats of 'observer biases were addressed through the prolonged deep engagement with the two teachers, and also by researcher reflexivity. I disclosed my personal beliefs and biases with regards to the implementation process of the Mathematical Literacy curriculum to the participants, and was further self aware of these beliefs and perceptions throughout the study, as to how they may potentially bias the research process and interpretations drawn. The data was crosschecked by participant feedback allowing the two teachers an open an honest discussion on their views on my interpretations. This method of member checking further augmented the verification of the findings.

4.6 Data Analysis

The data analysis was conducted throughout the data collection process. Emerging themes and patterns were used to refine and revise the data collected. This iterative and interactional approach pointed to redirecting the data collection in several instances as it allowed for "the testing of emerging concepts, themes, and categories against subsequent data" (Merriam, 2000:14). Within case and a cross-case comparison was also carried out, contrasting and comparing the data collected with each other, with the propositions of the conceptual framework and with the relevant body of theory. Peer review throughout the study was also used in order to confer thoroughness and credibility to the analysis. This method furthered and developed triangulation during the analysis process, which was necessary and indispensable to this qualitative inquiry.

In the defense of the research proposal I had included the use of the software AtlasTi as a means by which I was going to facilitate the analysis of the data. It was anticipated that the open-ended questions and interviews would elicit large amounts of narrative text, which would have been more manageable using a software programme. However, I found that starting early on in the data collection process with the analysis, the use of a structured and color coded word document served this same purpose well and as such the Atlas Ti software was never used. Segments of the data were marked and coded which enabled its conversion into meaningful analytical units. The codes were initially a *priori*, guided by the theoretical propositions, but as the research continued inductive codes generated by the data were also added and used. Patterns in the data, from the various sources were identified and used to inform the interpretation thereof, by matching them to each other and the actual propositions. This methodical and meticulous approach supplemented the trustworthiness of the findings.

In analyzing the data, I followed the four steps advocated by Yin (2003:137) for a high-quality case study analysis. I began by ensuring that I "attended to all the evidence" so that the interpretations made were not "vulnerable to alternative interpretations". Secondly, where needed and where possible my analysis addressed 'all major rival interpretations' as a means to ensure and achieve a deep and meaningful understanding of the results. Following this, I looked at the 'most significant aspects' of my study, my propositions, and how they related to the findings, so that my analysis would not diverge from the actual purpose of the study .To conclude the analysis, I used what Yin (2003) refers to as 'prior, expert knowledge' to develop a rich, vivid and descriptive narrative true to the findings. This ‘expert knowledge’, included sixteen years of teaching experience in mathematics. I do concede however that this knowledge and experience has intrinsic subjective bias as it forms part of my identity.

4.7 Ethical considerations

The rights and dignity of the two teachers were respected and upheld during and after the study, as was the non-disclosure of their identities, even though, according to Yin (2003), the disclosure of identity was the most desirable option.

Classroom visits in South Africa are commonly seen as 'inspections' during which the ability of the teachers is judged, and thus have become highly sensitive in nature. As such it was a privilege to be allowed access to classroom observations by the two educators for the purpose of this research. It became imperative that the two teachers in this study understood that the study would not affect their standing in the school or in the teaching profession in any way, by ensuring that their identity was kept confidential in the report. This confidentiality however precluded the research sites, as I had to obtain permission from the principals of these schools to conduct the study. To ensure that the respondents would be comfortable with the findings, if they were to be read by their principals I offered to allow them to edit any sections in the chapters pertaining to them. Neither respondent took up the offer.

Informed consent was obtained from both the participants, as was permission from all the relevant authorities and schools before the fieldwork proceeded. Additionally it was made clear to all what the purpose of the study was, the foreseen benefits to them and me and the discomforts that may arise. Such honesty was essential for building a trusting relationship with the participants, which was fundamental to this qualitative research.

4.8 Chapter Four Summary

This chapter describes the qualitative research design that was employed to study the three research questions and test the propositions as provided for by this study. I explain the rationale for the employment, and highlight the difficulties encountered in finding willing participants. An overview is also given on the dynamic adaptation of the design as initially thought out and as affected by the realities of actual fieldwork. Ethical considerations and issues of trustworthiness are also accounted for herein.

Chapter five follows and gives snapshot findings on how teachers view and instruct the new Mathematical Literacy curriculum.

CHAPTER 5

A Snapshot Survey:

What Mathematical Literacy teachers claim about the new curriculum.

5.1 Introduction

The initial design of this research included two in depth case studies. However over the past two years I was privileged with the opportunity to meet and talk to fifty-four mathematical literacy educators during workshops, conferences and cluster meetings[12] that I attended for Mathematical Literacy. I was also privy to a discussion forum set up on the Internet to deal with issues and questions pertaining to the FET curriculum in Mathematics, which was then extended to include Mathematical Literacy.

I have taken the decision to include some of the revelations of both the informal discussions and also the questions raised and points made on the Internet forum, for not only is the design of this study an explorative one, but many of the findings resonated with those of the two case studies. The numbers of educators 'interviewed' do not represent a significant statistic and nor do the number of users of the Internet forum, and as such the revelations go towards being the embedded units of analysis in this research.

The emerging data might also point the way to future studies in mathematical literacy. In particular, as a field, and how it pertains to educational change in emerging democracies.

The findings have been grouped into categories that capture the emerging themes of the two case studies. They are given in point form, followed by a numerical representative statistic and are then given evidential depth by the most direct quotes, and/or electronic discussions on the Internet forum.

[12] Professional learning communities designated by educational authorities.

Emphasis has been added on the codes that communicated similar themes in the two case studies.

5.2 Emerging Themes

5.2.1 Threat to 'status-identity'

1) Qualified mathematics educators are hesitant to identify themselves as mathematical literacy educators, always ensuring that they make it known that they also teach mathematics (46 of 54 teachers).

> *"I teach one class of mathematical literacy but I am a Mathematics teacher. All my other classes are maths, Higher Grade Maths!"*
>
> *"I am not a mathematical literacy teacher. I saw the opportunity to get into a private school and took it. Now, I am not sure that I have done the right thing. People must not think that I am not a Mathematics teacher".*
>
> *"We will rotate the teaching of mathematical literacy in our department each year, because we do not have a mathematical literacy teacher. We are all Mathematics teacher".*
>
> *"I was told I would be taking over the mathematical literacy last week. I have resigned, because I have no idea why I have been demoted".*

2) Educators of mathematical literacy in private schools are either new educators to the school, mainly from government schools, or are the teachers in the department that previously taught standard grade mathematics. This is because experienced higher-grade mathematics teachers do not want to teach mathematical literacy (11 of 12 'private' schools).

> *"This is my first year at St. George. They had my CV for three years before they appointed me. I was phoned at the end of last year (2006) and asked if I wanted to come and teach mathematical literacy. I took the job so that I could get out of the government school I was teaching in. Nobody in the department wanted to teach mathematical literacy.*

Now I see why, the mathematics teachers are treated differently, everything revolves around them".

"I was given mathematical literacy to teach because I have always taught standard grade mathematics. None of the higher grade teachers would do it; they think they are too clever to teach this subject".

"Maths teachers think that they are too good to teach mathematical literacy. It is like you either teach mathematics or you do not. But now at least I am in a private school, with time I will prove myself and ask to be given mathematics which is what I am qualified to teach."

5.2.2 Lack of Leadership: Absence of Collaboration and Reflection

3) There is a lack of leadership, discussion and reflection in the teaching of mathematical literacy. This is due to the fact that Heads of Departments do not teach mathematical literacy, nor do they engage with the teachers on how the implementation is taking place with any significant depth (23 of 24 schools).

"I appointed someone new, from a government school. My staff refused to teach maths literacy. The new teacher is fine, she keeps telling me that it is going well, I can see this because the pupils are happy", (H.O.D - Private School).

"I teach the Mathematics. I have given the Mathematical Literacy to the teachers who would never be given Matric Higher Grade Mathematics to teach. It seems to be going alright, you know how it is, in private schools if there is a problem the parents will tell us", (H.O.D.-Public School).

"I asked at the conference if mathematical literacy user groups would be set up. They told me it was a good question, but they have done nothing about it. At the maths user groups nobody discusses the mathematical literacy, you feel stupid, because the maths teachers are thinking who cares, you try teach the new core Mathematics".

- **Sent: 6October 2006 7:18 AM**
  To: ...@yahoogroups.com
  Subject: RE Maths Literacy-an online chat

  Spoke to my HOD regarding doing both Math and Math Lit. She is unaware that a pupil may not do both. Please could you clarify?

5.2.3 Thin and Disconnected levels of Understanding: teaching 'mathematics in context'

4) In private schools, content is often taught first with the application of contexts following (11 of 12 schools).

> *"I teach all the maths first. It is important to establish the basics first. Once they have acquired these mathematical skills I introduce them to contexts".*
>
> *"I focus on teaching the mathematics first. If they can do the maths, the application is easier".*

- **Sent: 10 October 2006 02:05 PM**
  To: ...@yahoogroups.com
  Subject: RE Maths Literacy-an online chat

  Some of the concepts are involved and starting in Grade 10 gives me the time to go through many basic concepts, which these kids invariably never got previously. E.g. rounding off, percentage, working with simple formulae, basic graphs etc. My method of teaching has been to teach skills first, then give them scenarios we would use that skill in. I found in many of the textbooks that they have huge scenarios with many, many different skills needed to answer all the questions-which would mean I have to stop start all the time.

5) The teaching of content and context as a process manifests itself more readily in schools were the teachers were not previously teaching senior higher-grade mathematics (11 of 17 schools).

> *"I use to teach Grade Eight and Nine mathematics only. I am pleased that I have been given the opportunity to teach the seniors now. I take contexts that are rich in mathematics and are also enjoyable to the pupils. We explore these and without even realizing it, the pupils are learning mathematics".*
>
> *"My other teaching subject is Biology. Now I teach Mathematical Literacy and Biology. I choose themes that have maths in them, and through these broad contexts allow the pupils to understand how maths is found nearly in all that is known and that they do".*

5.2.4 Value of Mathematical Literacy

6) Private school teachers believe that the students are enjoying mathematical literacy and are copying well with the curriculum. Furthermore they believe that their students find that they are doing a subject that benefits their everyday lives (9 of 11).

> *"The pupils love coming to my class. They keep telling me how much they are enjoying maths literacy. For some of them it is the first time that they are passing mathematics with a decent mark. I think they are enjoying it so much because they can finally see how mathematics is relevant to their lives".*

> *"My girls keep telling me how happy they are that they no longer have to be scared of attending a maths class. They are enjoying doing something that they can see the relevance of".*

- **Sent: 29 September 2006 03: 33 AM**
  To: ...@yahoogroups.com
  Subject: RE Maths Literacy-an online chat

  I am finding ML a wonderful subject to teach and really experience the feeling of empowering students.

- **Sent: 29 September 2006 07:33 AM**
  To: ...@yahoogroups.com
  Subject: RE Maths Literacy-an online chat

  Maths Lit seems to be going well with us at *School K*. It has given students who really struggled in Grade 8 and 9 a new lease of mathematical life-and they are really enjoying it, and experiencing some success at last.

- **Sent:05 October 2006 07:05PM**
  To: ...@yahoogroups.com
  Subject: RE Maths Literacy-an online chat

  Thoroughly enjoyed teaching ML this year, particularly with my Geography background. The pupils have also loved the subject.

- **Sent: 10 October 2006 02:05 PM**
  To: ...@yahoogroups.com
  Subject: RE Maths Literacy-an online chat

  I have taught Maths Literacy in Grade 10, from the beginning of the year. I have found it beneficial in every way. Not only have I been able to

> consolidate a lot of the "basic" concepts but also more importantly I have seen such a change in the learners in my class. They really are not scared of Maths any more. They tell me they no longer dread is as they actually now realize they CAN "DO" MATHS. Their self-esteem has improved and their confidence has grown to the extent that they readily say they don't understand or they ask tons of questions and because our class is small, they don't feel inferior because they don't know. I have thoroughly enjoyed teaching Maths Lit this year. I am excited for its future and believe that soon children and teachers will see the benefit of this awesome subject!

7) Public school educators believe that the curriculum is too difficult for the cohort of student doing the subject, and furthermore that it has no real value (19 of 21).

> *"It is too difficult for these pupils. They are struggling with all the reading. They are already the weaker pupils now they must do mathematics in questions that are long and require a lot of reading. And for what, it closes so many important doors at university".*

> *"We are wasting our time. It is too difficult for the learners. They need to learn basic mathematics that is what is important when they leave school. At least with standard grade mathematics, they were exposed to real maths. This is lower than lower grade maths. What is the point"?*

> *"The pupils hate mathematical literacy. They feel that they cannot use it to study further. They want to do careers that require proper mathematics. At least with standard grade mathematics they could still get into some of these careers. Telling them it helps in everyday life is pointless, if what they want to do is change the life they find themselves in".*

5.3 Synthesis

The emerging themes bring to the fore several considerations for official policy makers, and mathematical literacy stakeholders.

Firstly, the threat to 'status identity' is considerably affecting the way teachers relate to and with the mathematical literacy curriculum. As qualified mathematics teachers they have a strong subject identity. Their perception that this identity is lessened when teaching mathematical literacy, instead of mathematics, is being "felt as a threat to [their] identity" and is being "experienced as a pollution endangering the sacred" (Bernstein, 1971:56).

Secondly, in the absence of leadership, collaboration and reflection, mathematical literacy teachers are not only feeling isolated from their mathematics department but are implementing the subject mostly based on personal interpretations. This isolation not only feeds the threat to the status identity but also contributes towards the third theme, that of thin and disconnected levels of understanding the nature of teaching of 'mathematics in context'.Teachers, value mathematics as an absolute truth and their philosophy on what mathematics instructional practice should be is based on many years of teaching experience both as pupils themselves and as educators. Any deviance from presenting mathematics in a way different from tradition is not deeply understood as it questions and challenges what they hold as the superiority of naked and abstract mathematics.

Lastly, the value held for mathematical literacy differs along socio-economic lines. Teachers at private schools believe that the subject is valuable for their pupils in that it empowers them with knowledge and skills that have real-life benefits. Their counterparts in government schools hold opposing views. Here, mathematical literacy is viewed as a subject that closes doors to tertiary studies, and as a subject that is not 'real' mathematics.

These findings will not be analyzed explicitly any further as they do not form part of the case studies. They are however used as previously mentioned as embedded units of analysis in recognizing and further authenticating some of the emerging themes from the case studies. In addition this short chapter ensures that this data is not lost, as it may allow for further more comprehensive studies.

In the next chapter I make available a report on Norman Mhuka, the first case study respondent of this research.

CHAPTER 6

The case of Norman Mhuka: 'The maths of oranges and bananas'

Maths literacy is about teaching maths in context.
It is the maths of oranges and bananas.
Unfortunately the pupils are not finding it easier and many of them are still failing.[13].

6.1 Introduction

In this chapter I explore Norman's understandings and perceptions with respect to the new mathematical literacy curriculum, and the bearing this has on his actual instructional practice. The emerging themes from the data collected, following the methodological strategy outlined in Chapter Three, are identified, explored, interrogated and analyzed, building an explorative case study that embodies Norman Mhuka's understanding and enactment of the mathematical literacy curriculum.

Contrasts and similarities between the findings and the *National Curriculum Statement Grades 10-12 (General) Mathematical Literacy* are further described and discussed (DoE 2003). I begin by describing how I came to know Norman, I offer a snapshot of Norman's *curriculum vitae* and who Norman the person is, and I conclude with a depiction of the context in which he teaches and a profile of his Grade 10 mathematical literacy class. Having detailed the implementation context, I proceed with an in-depth analysis of his understandings and perceptions of mathematical literacy as concept and subject. The discussion ends with narrative report on his actual instructional practice. The reasoned logic informing his understanding and practice will be provided in Chapter Eight of this dissertation, together with the theoretical analyses of this data.

[13] Excerpt from interview with Teacher Norman in the course of conducting this research (July 2006).

6.2 Finding Norman Mhuka

After the first two unsuccessful attempts to find respondents to this research, which I explained in Chapter Four, I was pleasantly surprised at the ease of finding Norman. I had made an appointment at East Rand High School and went to meet the principal. Telephonically I had already explained the purpose of the study to the principal, to which he had responded, what seemed at the time, very enthusiastically. On arrival, and after a few minutes of talking, my first impression of his willingness was justified when after the short discussion he called, over the intercom, the two teachers teaching mathematical literacy at East Rand High School.

I explained the research to these two teachers, with the principal occasionally interjecting, and then I proceeded to ask the educators to think about participating in the study and getting back to me if they would be willing. The one educator, Norman Mhuka, immediately responded that he was willing to be part of the research study. The second educator was friendly but unresponsive. The principal printed a copy of Norman's timetable and we agreed, on the day, that the research would commence.

At this point it is important to mention that during my application for ethical clearance it was drawn to my attention by one of the reviewers that approaching the principal first might raise questions of ethical concern. The reviewer pointed out this may include an obligation that an educator may feel on been approached by the principal and also that the eventual results would at a later stage be available to the principal which may pose difficulties for that educator.

Being aware of this and the fact that the principal's enthusiasm was evident to the educator I made it very clear when I met up with Norman, the very next day, that he could at anytime withdraw from the study and that the principal would be informed by me that my research at his school was complete. Norman seemed at ease with having volunteered and his willing participation may be a reflection of his own academic interests in further studies, which I was to find out at a later stage.

6.3 Curriculum Vitae - Abridged

NORMAN MHUKA

DATE OF BIRTH

2 April 1968 (38 years old)

EXPERIENCE

1990 – 1999 Zimbabwe High School

- *Mathematics Educator Grade 8-10*

2000 – 2003 Johannesburg City Center College

- *Mathematics Educator Grade 12*

2000 – Present East Rand High School

- *Mathematical Literacy Grade 10*
- *Mathematics Grade 10 & 12*
- *Life Orientation Grade 10*
- *Life Science Grade 10*

Other duties:

Tennis Coach & Hockey Coach

EDUCATION

1986–1988 Zimbabwe Teacher training College
3 Year Teaching Diploma: Majors, Mathematics & Biology
1989 Zimbabwe Teacher Training College
Further Diploma-High School Teaching

INTERESTS

Art, Hockey, Tennis

Norman is a thirty eight year old male who is well groomed and what would be called a 'gentleman' in the old-fashioned way. He is extremely respectful and polite. He has been teaching mathematics for the past seventeen years. His career began at a high school in Zimbabwe, which was then followed on his arrival in South Africa with teaching at a college in the city center of Johannesburg, which mainly focused on grade twelve learners that had at previous attempts failed their grade twelve year or had not attained a pass in higher-grade mathematics.

This experience he explained was very taxing and although he felt rewarded when several of his learners, on repeating grade twelve, passed mathematics on the higher grade, the lack of resources and crime in the area forced him to apply to other schools. When the opportunity to teach at East Rand High School was given to him he was excited to teach at what was previously a 'white' school. This was grounded in what he believed would be a safer school and much better resourced.

On arriving at East Rand High School he soon experienced what he refers to as 'black on black racism'. Most of the parents, irrespective of their race, wanted 'white' educators teaching their children. At the time, there were two other mathematics teachers, both white, and he repeatedly received complaints, particularly from the 'black' parents who always asked for the 'white' educators. Over the next couple of years the two other educators left ERHS and 'black' educators were appointed in their place.

This however did not alleviate the complaints Norman was getting and he soon experienced harsh xenophobic attitudes to Zimbabwean nationals from many of the parents and learners. He persevered through this, and has found that over the past two years that the attitudes of both parents and learners have changed towards him, his nationality no longer being an issue. In his opinion the complaints that he does receive now are mainly rooted in the fact that he is not willing to compromise his standards. He proudly explains that his learners achieve the results that they are worthy of, as he will not lower his standards to appease complaining parents.

Norman loves art and while studying to do primary school teaching in Zimbabwe took Art as one of his major subjects. He would like to start an art club at the school for he finds interacting with learners outside the classroom to be very important in forging relationships with the learners that are conducive in the actual classroom. He is also a sport enthusiast, having played both hockey and tennis during his secondary and tertiary studies in Zimbabwe. Both these sports are offered at East Rand High School but Norman finds it difficult to field any one team as the learners, he says, lack both motivation and commitment to extra-mural activities.

Norman left Zimbabwe at the end of 1999 together with his wife, for he felt that he could not support his family in a way that he would like to. He left his two young daughters behind, to be temporarily looked after by their grandparents with the intention of bringing them to South Africa once he and his wife were financially secure and settled. This has taken longer then initially expected, but believes that he needs to do this soon for now they are of school-going age and he would like them to attend an urban school in South Africa. Furthermore his wife has recently also managed to secure work doing AIDS counseling in one of the country's large banks that pays substantially more than her first job at the Grain Board. Norman freely talks about the difficulty of being separated from his children and on how on a monthly basis he sends food parcels to his family in Zimbabwe which include fresh milk and bread, through a truck driver that he was introduced to while working in the Johannesburg city center.

Norman's home language is Shona; however he is very proficient in English. He received his initial training in primary school teaching at a Teacher's Training College in Zimbabwe. He studied mathematics, biology and art. On completing his teaching diploma he decided that he would be better suited to a secondary school environment and preceded to study for one more year, which entitled him to teach mathematics and biology to high school learners. In recent years he has attended an outcomes based education workshop, an assessors course and, during 2006, a workshop on mathematical literacy.

His teaching experience spans seventeen years at three different schools, two in South Africa and one in Zimbabwe. He is currently teaching Mathematics to Grades 10 and 12, Life Sciences to Grade 10, Life Orientation to Grade 10 and Mathematical Literacy to one Grade 10 class. Apart from his teaching duties Norman is also responsible for a homeroom class, which he sees on a daily basis, monitoring absenteeism and the schools code of conduct on learner dress and appearance.

The school timetable consists of twenty-five one-hour periods of which he teaches sixteen periods. He uses the nine remaining hours to do his marking, administration, setting of assessment tasks and general academic planning. His school day begins at ten to eight in the morning and ends at five past two in the afternoon, with two twenty minute breaks in the course of the school day. His classroom is situated on the lower level of the school and the learners' come for both registration and teaching to his classroom.

He is again looking to leave his current workplace but this time the reason is that he believes that he is in line for promotion. At the time of the study Norman was a level one educator[14] and he hoped for a Head of Department promotion or even a Deputy Principal position. Furthering his studies is another option but has not managed as yet to register for a course of his choice due to the financial constraints.

This profile of Norman was informed by casual conversations over the six-week observation period and also by the questionnaire (Schedule A), which had the objective to gather information on the educator's background. This outline is indispensable to establishing the core to such a study since individual and professional qualities are inextricably connected to what people declare and practice. As such, this individualized context enriches the study by providing a more holistic lens for interpreting the findings of the research, as does the environment in which Norman teaches. This is described below.

6.4 Norman's teaching environment

East Rand High School (ERHS) is situated forty-five kilometers east of the Johannesburg city center. It is an urban school located in a predominantly Afrikaans speaking town that opened its doors to all races in 1992. Since then its racial identity has grown to ninety five percent black. It is still, and has always been, the only English medium high school in this town.

[14] A Level 1 teacher is an educator that does not have a promotion position. The levels in primary and secondary schools range from 1-5,with level 2 been Heads of Department, level 3 Deputy Principals and levels 4 and 5 Principals the difference being learner number dependent (Employment of Educators Act - 1995).

A principal, two deputy principals- one female and one male- and thirty-three teachers constitute the academic staff at ERHS. Interestingly, of the thirty-three academic staff twenty-seven are female with the six remaining male staff either teaching mathematics or science. The mathematics department itself is four educators strong, all of them black male. The racial composition of the remaining twenty nine academic staff members, in terms of race, is majority black South African, with four white South African female teachers and three black Zimbabwean males. The description of Norman's teaching environment in terms of race and ethnicity is provided, as it was a basis for the hostile experiences, in terms of xenophobia and racism that Norman experienced for several years at ERHS.

Male educators with the exception of the one female deputy, hold all the promotion posts, which include one principal, two deputy principals and five heads of department. The administrative staff is all white and female. There is a general secretary, the principal's secretary, the school typist, the school financial controller and a second typist who is also the laboratory assistant. The auxiliary staff includes a kitchen worker, a caretaker and several ground staff cleaners whom he supervises.

ERHS has a governing body, which is democratically elected by the parent body. However there is general consensus in the staff room that the governing body oversteps the boundaries and involves itself in areas that they should not. These areas include actual teaching ability and staffing. The principal is aware of his staffs' feelings and readily admits that he absorbs a lot of the complaints so that his educators are not demotivated or feel threatened even further. There are also grievance procedures in place for both the educators and learners which both parties can make use of through their respective elected representatives. Several staff is of the opinion that a procedure should also be put in place for the parents, as they are a major source of staff unhappiness and unease.

ERHS runs from grades eight to twelve and has eight hundred and seventy three learners registered on its school records. The learners attending the school are mostly from the surrounding two townships with a small minority that actually live in the town itself. A neighboring squatter camp[15] also feeds some learners to ERHS but this is only a handful, as these parents cannot afford the required school fees. Racially the percentage of black to white learners is ninety-five to five, with the five percent having English as their home language and the majority an African home language. Most of the learners at ERHS did however receive their primary school tuition with English as the medium of instruction.

ERHS is on the northern outskirts of the town in which it is situated. It is easily accessed by any of the four tar roads that surround it as it occupies an entire street block. The school building and grounds have a high-wire mesh fence that encloses it and an electric gate at its main entrance. The intercom at this gate was not functioning during the entire research period and one was required to either hoot for it to be opened or to phone the secretary of the school on arrival. A walk-in gate is situated near the electric gate and this was found to be always open during the duration of the study. A steady trickle of learners, in and out the school, was visible at most times during the school day.

The school is a two story brick building with a tin roof, thirty seven classrooms, one library, one computer laboratory, two science laboratories, one biology laboratory, four learner ablution blocks, two upstairs one for males and one for females and two similarly distributed downstairs. The staff toilet facilities are on the downstairs level only, male and female separate. These are kept locked with staff having a key to prevent theft of soap and towels, which has occurred in the past. In addition there is a carpeted staff room with several round tables and chairs and an adjoining kitchen with a fridge and a microwave. There is also a tuck shop were the learners can purchase lunch or snacks at either of their two breaks. Vendors selling sweets and cool drinks dot the pavement area outside the schools main gate every weekday afternoon and the learners make prolific use of the vendors' trade.

The computer laboratory was funded by a nationwide project for government schools which provided for twenty-five computers and two printers, all still in good working

[15] Squatter camps are informal settlements that have mushroomed all over the South African urban landscape reflecting the poverty that the majority of South Africans still find themselves in.

order. These may be used only by the learners who take Computer Studies as a subject from Grade 10 onwards, with the room been out of bounds to all other learners. During this study it translated to approximately seven percent of learners being allowed to use the computer laboratory. The Internet is only accessible to the Principal and the Deputy Principals who have got dial-up connections in their offices. The learners may at no time use the Internet facility and staff needs to motivate in writing if they require the use of the Internet. If deemed necessary, the research is then done by either of the two Deputies and the relevant material is printed out for the staff member.

The library in turn is well stocked with many shelves of books neatly arranged with codes and a catalogue. On closer inspection, however, it was found that most of the books were dated and were last used in the late 1980s with the new reference books being mainly free copies of new OBE and FET textbooks from various publishers. The library remains closed to the learners to prevent theft, and only staff may check out books that they require for planning and or teaching. There is also an outbuilding, the old woodwork center, however this subject is no longer offered to the learners due to the cost of running the center. The caretaker and his staff use this part of the building to do repairs on broken chairs and desks for it is still stocked with many tools and several machines.

The administration block is situated centrally in the school and is accessed via an open foyer decorated sparsely with antique pieces, a ball and claw sofa, a ball and claw table and two 'Singer' sewing machines, all evidence of the past affluent history of the school. The principal's office has an adjoining secretary’s office outside which, a spacious reception area is situated, furnished with two chairs and a sofa. The typist’s room on the opposite side of the reception area houses the two photocopiers that service the entire school. The deputies also have their own offices as does the schools financial assistant.

The classrooms are relatively big and accommodate on average thirty-five single wooden tables and chairs. The classrooms like the rest of the building are wired with electricity, have good lighting and have at least one plug point. Furthermore all the classrooms have a green chalkboard in the front, a teacher's desk and chair, a locking cupboard for storage of learning and teaching material and many burglar barred windows. All of the laboratories also have burglar gates on the doors, as do the sides of all the corridors. These are kept open during the day and locked up at four o' clock on a daily basis. This has reduced the vandalism and theft that use to occur prolifically in the mid 1990's.

In nearly all lessons, learners have their own chair but in some of the bigger classes learners share the single desks. Norman's class is no exception barring the lack of graffiti on both his desks and walls than in many of the other classrooms.

The school has extensive fields, with an athletics track, two soccer fields, three-hockey fields and an area demarcated for cricket. The fields need minor maintenance in terms of painting the lines that differentiate the various positions and areas on the fields. There are also three tennis courts that need some surface maintenance and a shooting range that is no longer used. After the apartheid government, the rifles that the education department provided the school with for a subject that was then know as Youth Preparedness was discontinued. The parking facilities for the staff and visitors are extensive and neatly cemented, and several trees can be used for car park shading.

All in all the school is in a relatively good condition and conducive to learning, with some painting and minor repairs needed in various parts. Even the litter is maintained to a minimum as cleaning the school is one of the disciplinary measures that the principal has introduced. Instead of suspension, after a series of infringements on the school code of conduct, the learners are giving orange overalls to wear and they spend the day cleaning up the litter.

Educators need to be at school by five to eight as registration takes place at eight o'clock and may leave school at three o'clock. Most of the staff however leaves at five past two, which is also the end of the school day. The academic staff is not expected to do extra mural activities, as these are optional for both the learners and the staff. Priority is given to academics and the educators are expected to stay twice a week offering free tuition until three o clock for learners requiring academic assistance.

6.5 A Snapshot of Norman's Grade 10 F Mathematical Literacy Class

There are thirty-eight learners in Norman's mathematical literacy class. The majority of these learners either failed Grade 9 Mathematics or attained a promotion mark that was a pass mark but failed the end of year examination. The learners that failed mathematics on the promotion mark were condoned to Grade 10 on condition that they do Mathematical Literacy and not Mathematics; for those that failed the end of year examination but passed on the promotion mark mathematical literacy was highly recommended by both the Head of Department and the Principal. ERHS has two more mathematical literacy classes with thirty-five learners and thirty-eight respectively, which Norman's colleague teaches. Together the three classes represent a seventy one percent majority of Grade 10 learners doing Mathematical Literacy instead of Mathematics.

The home language of the learners in Norman's class is varied and includes Sotho, Zulu and Sepedi.However, the learners are relatively proficient in English and most of them attended the neighboring English medium primary school. Absenteeism is minimal and during the six-week observation period the highest absenteeism on any one-day in Norman's class were four out of the thirty-eight learners. The ratio of boys to girls was nearly even and, with the exception of two white girls, all the learners were Black African.

The learners do not have mathematical literacy textbooks nor do they have scientific calculators of their own. They have a writing book, which is used by many to take notes in at least two learning areas. From front to back the mathematical literacy notes are evident, from back to front the notes of other subjects appear and in some of them from the middle of the notebook onwards the notes of a third subject are also apparent. The learners are outspoken and there is an overwhelming sense of disrespect for the educator. Continuous talking throughout the lesson is common as is the 'back chat' when Norman attempts to discipline the class.

The learners are taught in Norman's classroom, which is a typical example of most of the ERHS classrooms barring the distinct absence of graffiti, as previously mentioned. The walls have no posters and the only writing includes faded formulae of three trigonometric identities. The desk are arranged in tightly packed horizontal rows and once the learners are all seated it becomes difficult to move around the room as the desks, chairs and school bags occupy most of the floor space.

Norman Mhuka claims that this is one of the better schools in terms of resources and academic offerings in the surrounding area and often points out that many of his colleagues from neighboring schools would like to work at ERHS.This is also evident by the large number of learners that are on the waiting list to attend this school. As a government school the school fees are manageable for most of the parents of the learners that attend ERHS and it is preferred over the township schools that both the educators and learners of this community believe to be worse off.

Having sketched the context in which Norman operates as a mathematical literacy educator, I will now proceed to discuss how and why he teaches as he does. The three research questions posed in this study will be sequentially addressed through descriptive analyses of the findings.

6.6 Norman's understandings and perceptions of the purposes, problems and possibilities contained in the mathematical literacy curriculum

In this section I explore and describe Norman's understandings and perceptions with regard to the new mathematical literacy curriculum, as a response to the first research question: What do teachers understand to be the purposes, problems and possibilities contained in the mathematical literacy curriculum? The evidence is elicited from the semi-structured interviews that preceded the classroom observations (Schedule C), casual conversations and the semi-structured interviews that were held after classroom observation (Schedule D), the questionnaire containing both open and closed ended questions (Schedule A), an in- depth document analysis of curriculum and related guidelines (Schedule G), and notes from the researchers journal (Schedule J). An explanatory theoretical analysis of the findings will follow this description and exploration in Chapter Eight.

6.6.1 Identity dilemma

Norman received his teaching timetable for 2006 on the first school day of that same year, which is also the time at which he became aware of the fact that he would be teaching mathematical literacy. He had heard about the subject in the latter part of the previous year but was unaware that this new subject was going to be offered at ERHS and that he was going to be asked to teach it. He received a personal copy of the mathematical literacy curriculum from his head of department and was told to conduct weekly planning as he was going to be in charge of the subject for the year.

Norman's head of department also gave him three mathematical literacy textbooks that he was to use to teach the class assigned to him. That was the only discussion that Norman had about the teaching of mathematical literacy with his head of department, or any other member from the mathematics department at the beginning of the school's academic year. He was not particularly concerned at the time because he had heard that this was an easy subject for the learners that could not do mathematics, and he had textbooks from which to teach. What was of concern to him was why he was given mathematical literacy to teach in the first place:

> *It did not worry me that I had to teach mathematical literacy, I knew that this was an easy subject. I did wonder however why I was told to teach it. I would rather teach mathematics that is what I am qualified to do. If it does not matter who teaches the subject why did my head of department not take a class? As long as they do not think that I am going to become the maths literacy teacher at the school. Then I will leave to pursue further studies, which is something I have always wanted to do.*

Norman's response indicates that he felt offended at having to teach mathematical literacy. This cuts to the core of how he views the subject, possibly as a subject with little academic standing or at least lesser than mathematics. Inquiring deeper on why he did not want to be known as a mathematical literacy educator Norman explained:

> *Because the subject is for the 'doffies'[16], you know all those pupils who cannot do mathematics, and I do not want to be the teacher thought of in the same way, the teacher who cannot do mathematics. The parents, they will think like that, he is teaching mathematical literacy because he cannot teach mathematics properly.*

This perception of Norman's that teaching mathematical literacy somehow reflects on his inability as a mathematics educator, raises more fundamental questions. Why does he harbor such negative feelings and perceptions with regards to teaching the subject? Are they founded in insecurities established at the onset of his teaching career at ERHS as a product of the complaints that he received from both parents and learners or are they a manifestation of his beliefs and understandings of what mathematical literacy as a subject symbolizes?

6.6.2 Broad understanding of implementation

In the questionnaire Norman indicated that he understood the mathematical literacy curriculum to a large extent but was not sure of whether it provided guidelines for implementation; at the same time, he considered its implementation as flexible. He further indicated that he did not have copies nor was he aware of the corresponding Subject Assessment Guidelines, Learning Programme Guidelines and Teacher Guide. This did not seem to matter to him and at no stage of the study did he ask for copies or a way to acquire these documents. He seemed more preoccupied with the exemplar paper[17] that he had obtained from another colleague at a cluster meeting:

> *Before I got this paper I was not sure if I was doing the work in enough detail or too much detail. This is the best thing that the department could have done; give us a copy of an example on how to set a paper. If I look*

[16] A colloquial South African word used to describe people with an inferior intelligence.
[17] The Department of Education during the course of the year posted exemplar papers on its *thutong* website in all the FET Grade 10 subjects.

> *at this paper I know that what I have taught this year is right. I have taught all these sections, if the pupils cannot do it, it is because they are weak and struggle in mathematics not because I did not teach them properly. As long as the pupils and their parents do not think that because now their children are doing maths literacy they will simply pass. They still have to work; it is definitely not an easy subject.*

He continued excitedly:

> *But the exemplar shows that what I am doing is correct. We keep talking about implementation and now that I have seen the exemplar I know I have successfully implemented the subject.*

Once again Norman returned to justifying his teaching ability, which was never questioned or inquired about during the interviews. Yet his insecurities seem to be deeply ingrained, even overpowering, as he kept bringing them to light. What did become clear was that Norman worked in a much pressured environment.

During a conversation with the principal he revealed that there was an expectation from the parents that having been told to do mathematical literacy because it was the easier option to mathematics somehow had led them to believe that this subject would not pose any difficulties and that their children would all pass. The principal had compounded this expectation when he admitted that he had reassured the parents that it was more difficult to fail mathematical literacy than it was to pass it, in order to encourage them to allow their children to take a subject that would ultimately be more useful to them and create less anxiety than mathematics. In so doing the expectations of both learners and parents was of an easier and stress free curriculum.

Moreover Norman clearly did not view the implementation of a curriculum as a dynamic process that can develop and unfold over a period of time, but rather as something he had already successfully achieved. His rationale was mainly based on the premise that since he had covered all the work in the sections that he had already taught with reference to the exemplar paper, he had successfully implemented the curriculum.

Norman attended a mathematical literacy workshop during the course of the year, which he had found to be of little benefit:

> *We wasted our time attending this workshop. All that they spoke about is in the curriculum; we do not need the learning outcomes read to us, it is something we can do for ourselves. They also told us what we as teachers should do but this is no different to what we do in all our classes. The only part that helped was some of the examples they did. But for me, well I can do this maths, perhaps the workshop should in future be for teachers that are not properly qualified, maybe they need to learn the maths. Once you know and can do the maths all you have to do is make sure that you are teaching it in a real life context.*

On viewing the notes and handouts that Norman had received at the workshop I found that the following topics had been covered:

- What is Mathematics Literacy?
- The Mathematics Literacy Learning Outcomes and Assessment Standards
- The Mathematics Literacy Learner and the Mathematics Literacy Teacher
- Overcoming Maths Anxiety
- Language and the Mathematics Literacy Learner
- Assessing Mathematics Literacy

What is of consequence is that Norman did not see any value in any of these as he had further described the course as a 'waste of time' and he seemed to focus more on his ability to teach the content, which he was well aware, had to be done within a 'real life context'. This phrase 'real life context' became Norman's pivotal focus on all that mathematical literacy entailed. To what extent he understood this and made use of it in his actual teaching, will be explored further in the ensuing discussion.

The curriculum document, the exemplar paper and the textbooks that Norman was using, were the only sources that Norman Mhuka consulted, and as such were initially assumed to have played the more significant role on his understanding of the new curriculum. However, psychological and emotional factors seemingly also impacted significantly on his responses and ultimate understanding. This finding, illustrated the complexity of implementation as a personal response. Norman's understanding of what mathematical literacy meant was similarly embedded in understandings that he had acquired over the course of his teaching life.

6.6.3 Concept Definition

As discussed in Chapter One, the definition of mathematical literacy varies widely even though it does have many commonalities. Norman's response to this question on the questionnaire was a brief 'real life maths'. During the interview he added, "A practical maths that enables you to get by with figures". The curriculum document shows his response to be partly aligned with the intended definition when it states that, 'Mathematical Literacy is a subject driven by life-related applications of mathematics' (DoE, 2003:9).

What is omitted however is a deeper understanding of an unambiguous 'awareness' of 'the role that mathematics plays in the modern world' and the requirement of 'critical analyses' of situations that may arise. Both the awareness and the critical analyses are explicitly stated in the definition of mathematical literacy in the curriculum document. This narrow understanding of the concept poses serious considerations on the impact this understanding of the defining feature of the new curriculum will have on how Norman proceeds to implement mathematical literacy.

What is further of interest is the confidence with which Norman responded to this question. There was no hesitation but a definite feel that he had given the correct answer to the question. This begs the question as to whether he will ever revisit his understanding of the definition and take the time to probe beneath this surface understanding in the absence of a reflective practice. What is more, does this understanding of the concept necessarily imply that the purpose will be understood in a similar way?

Norman's understanding of the purpose of the curriculum is given below, as it goes towards understanding what it is that he believes the reason for the introduction of this new curriculum was. This is important; for if he does not have a clear awareness of why mathematical literacy was introduced as a mandatory alternative to mathematics he may not proceed to implement this curriculum as intended.

6.6.4 Curriculum Purpose

The purpose of a curriculum normally specifies the value and reasons why a new curriculum has been introduced. Understanding this on a deep level may go towards understanding not only what it is that is to be implemented but also why.

Norman's understanding of why mathematical literacy was introduced was based on assumptions that he had made as nobody had explained the purposes of the curriculum to him:

> *I am not sure why it was introduced; nobody has explained this to us. But it may be because it is now compulsory to do either Mathematics or Mathematical Literacy and not everybody can do Mathematics. I suppose that they (Education Department) realize that maths is not like other subjects, not all pupils can do it. Therefore they have to offer another subject that is easier. So it is their way of keeping like a standard grade maths for the pupils. Mathematical Literacy is for the weaker pupils and they can use it in their everyday lives. It is not like the mathematics in the Mathematics syllabus, which is more like the old higher grade. That syllabus is mostly abstract and the pupils cannot understand why they even do some of the sections. For example, who uses geometry once they leave school? Hardly anybody not even those doing maths at university. The financial maths that is a new section in the Mathematics Literacy syllabus is much more beneficial to the pupils. They (pupils) will at some point or another have to use a bank and understanding their bank statements is very important.*

> He continued:
>
> *Mathematics Higher Grade is too difficult for most learners and the government wants the pupils to do some mathematics so that more pupils are doing the subject. I do not know why they changed from mathematics standard grade because that was much easier. It had less reading and because of this the pupils found it easier. With all the reading the pupils now have to do; mathematical literacy confuses them even further. I wish they (education department) would ask us what we think. I do not know of any school in our cluster that feels that this*

> *(Mathematical Literacy) is easy. Standard Grade Mathematics was already for the weaker pupil and most of the pupils doing standard grade did not go to university anyway. Know we have been told that they can go and do some careers at university with Mathematical Literacy, but how will they be able to pass this when it is harder than standard grade? Like I said we are all confused why this subject has been introduced, but I do see that it can have real life application, but not for the pupils who are already weak.*

Norman's response appears confused and convoluted. This may be because having admitted that he was not aware of why mathematical literacy was introduced, he attempted on the spur of the moment to supply an answer. An analysis of the response is however warranted as it reveals the following points of note, which are of relevance to this study.

Firstly his understanding that offering mathematical literacy is an alternative to mathematics is in line with the structure of the new FET requirements as is his continually repeated understanding of its application to 'real life' mathematics. Secondly, his response does not correspond to the purposes described in the curriculum document, which he has a personal copy of and claims to have read and understood. This includes addressing the poor quality of numeracy and high levels of innumeracy in mathematics in this country which are both elaborated on considerably in the curriculum document.

Thirdly several of his responses to the questions intended to explore his perceptions and understanding of the purpose of the curriculum were found to differ between the questionnaire and the account he gave above. In the interview as already declared he disclosed not having thought about why mathematical literacy was introduced and yet in the questionnaire he agreed that the subject was introduced because of the low levels of numeracy in the country.

Furthermore he indicated that he agreed that the reasons were political, and strongly agreed that the curriculum must be viewed in relation to the larger agenda of transformation. On probing deeper and asking him what he understood by the larger agenda of transformation as it relates to mathematics, he simply said, "I have no idea; my reply would be a guess".

The comparison of mathematical literacy, in his response, to standard grade mathematics further adds to the confusion that his response has already elicited, for in the questionnaire he clearly indicated that it was in no way the same as standard grade mathematics. And yet to some degree his reply shows that he does think of Mathematical Literacy and Mathematics having the same divisionary line as the old Standard Grade and Higher Grade Mathematics. What then becomes pertinent is not only the impact such possible confusion and superficial understanding will have on the road of implementation in his instructional practice, but also his acceptance of his own justifications and perceptions. Furthermore, how and why had Norman come to have this understanding?

Having indicated that he was not aware of the reasons why mathematical literacy had been introduced, he did not endeavor to inquire about this any further during this or any further interviews. This raises questions with regards to the implementation of this curriculum: If Norman's views and insights into the purposes of the curriculum remain unquestioned and unchanged, how will they impact the implementation of the curriculum as intended? And if they were to change what would bring about this change? Does holding a surface level awareness of the curriculum's purpose affect its implementation? Does holding a surface level awareness of the curriculum's purposes significantly affect understanding its possibilities?

6.6.5 Curriculum Possibilities

Working on the assumption that a deep understanding of what possibilities a curriculum can offer, significantly contributes to aligning the implementation of a new curriculum with its intentions, I proceeded to explore the possibilities on two levels. Firstly on a macro level inquiring about the possibilities that Mathematical Literacy as a subject has to offer, and secondly on a micro level which represents the possibilities contained in each of the outcomes.

6.6.5.1 Macro Level

On the questionnaire Norman indicated that he strongly agreed that mathematical literacy could enable learners to 'become numerically self-managing persons', 'contributing workers to society' and furthermore that it empowers them with 'democratic participation'. During an interview he had the following to say:

> *It gives the weaker pupils some skills that they can use in real life examples that require mathematics. It is a problem if you cannot understand situations that involve numbers.*

Although the response from the interview is brief, taken together with the evidence from the questionnaire, it seems probable that Norman can recognize the broader possibilities that the curriculum can provide for, even though he may not be able to articulate them as succinctly. Wanting to explore this further I selected the following sentence from the curriculum and asked him to explain to me how he understood it, 'To be a participating citizen in a developing democracy, it is essential that the adolescent and adult have acquired a critical stance with regard to mathematical arguments presented in the media and other platforms' (DoE 2003:10). After some though Norman answered:

> *Skills to tackle everyday maths problems. For example been able to calculate what percentage of your income you spend on groceries and other such expenses. The world revolves around money, and money is about numbers, so these skills are very important. There are many more, in just about everything you encounter on a daily basis.*

Norman's response, although in many ways accurate, lacks the depth that is actually required by the curriculum document. His focus is on the skills that are requisite for the actual calculations, whose importance can not be overstated, for there is always the danger that the mathematics will be overshadowed by the context when teaching 'mathematics in context' such as is required in Mathematical Literacy. However the exclusion of an understanding of critical discussion with 'regards to mathematical arguments' is noticeable, for the critical analyses of situations involving numbers is one of the empowering opportunities that this subject offers. On the other hand he did yet again recognize that mathematical literacy 'supports critical thinking' as evidenced in his response in the questionnaire but yet again was not able to convey this verbally.

This discontinuity in depth between his verbally articulated responses and those from the questionnaire are indicative of the lack of a holistic ownership of the curriculum. Having only been exposed to this curriculum for less than seven months this would not be a point of discussion if Norman in any way showed or expressed that he still used this document in any way other than to ensure that he had covered all the mathematical topics, for example; surface area, volume or compound interest. This absence of ownership becomes pivotal in the implementation for unless something or someone initiates Norman into making a further inquiry into parts of the document other than those discussed above Norman's perception and understanding will remain at this thin level.

Norman's understanding of the possibilities contained in the actual content of the curriculum was further also looked at, in order to establish whether he believed the curriculum content held any value. The supposition being, that if he valued the curriculum content, he may come to believe that the curriculum that he was implementing was worthwhile. This line of inquiry may help to further establish why he was feeling that mathematical literacy was the mathematics of "oranges and bananas".

6.6.5.2 Micro Level

I then proceeded to explore Norman's understanding of the possibilities that each of the four learning outcomes in the curriculum document could provide for. The inquiry around this was done with considerable scaffolding in the sense that each of the learning outcomes were read to Norman first as was their brief definition as given in the curriculum document. This scaffolding was provided because the use of outcomes in Grade 10 was only introduced in 2006, and the mind shift required of thinking in terms of these and not in terms of Algebra, Trigonometry, and Geometry will require some time for many educators, particularly those who have not taught Grades 8 and 9 in recent years (where outcomes have been in use), as was the case with Norman.

> Interviewer*: Learning Outcome 1 Number and Operations in Context The learner is able to use knowledge of numbers and their relationships to investigate a range of different contexts, which include financial aspects of personal, business and national issues' (DoE, 2003:11). How do you understand this outcome with regards to learner opportunities?*

> Norman: *This section is the financial maths section and provides many benefits to the learners as it teaches them how to use compound and simple interest and how to do their own personal budgets. This is new and was never dealt with in the past. The pupils find it interesting because they can relate to it. It is a very beneficial section in that way.*

Norman's response was not surprising, as he had already made several references to the financial aspects of the mathematical literacy curriculum. He seemed to enjoy and understand this section and from his response so did his learners. The curriculum document continues with delineating the focus of this learning outcome to be, 'on the investigation and solution of problems that require a sound understanding of numbers and their use in calculations, especially in financial contexts, ranging from personal to international issues' (DoE, 2003:p11). Norman's response is considerably similar to this explication particularly in terms of personal finance.

It is important however to point out that the contexts used need not only be financial. For example the curriculum document does not talk about simple and compound interest but more encompassing of 'simple and compound growth' (DoE, 2003:p38). The distinction is made here not because of the terminology itself but because of the opportunities that the learners may be deprived of if contexts are not used more broadly. Having said this however, the fact that Norman believes that his learners are finding the teaching of compound growth in teaching compound interest, interesting, is important for it further shows continuity with the curriculum documents discussion on how educators are to decide on contexts. The NCS Mathematical Literacy states:

> Contexts are central to the development of Mathematical Literacy in learners. Mathematical Literacy, by its very nature, requires that the subject be rooted in the lives of the learners. It is through engaging learners in situations of a mathematical nature experienced in their lives that the teacher will bring home to learners the usefulness and

> importance of mathematical ways of thought in solving problems in such situations (*emphasis added*) (DoE, 2004:42).

Norman viewed this outcome in a similar manner, as both useful and beneficial to his students. This valuing of *Learning Outcome 1* was however at odds with the lesser value that he had ascribed to the curriculum as a whole. Was this disparity a reflection of his unease at having to teach mathematical literacy and the broader implications this had on his 'status-identity'? How did this conflict between what he did value and what he believed others valued affect the implementation of this curriculum in his actual classroom? Did this deeper sense of what possibilities this outcome could offer run through into the other learning outcomes, like *Learning Outcome 2*?

> Interviewer:*' Learning Outcome 2 Functional Relationships. The learner is able to recognize, interpret, describe and represent various functional relationships to solve problems in real and simulated contexts.' (DoE, 2003:12). What possibilities in terms of real life applications does this outcome afford the learners?*
>
> Norman: *The application of this outcome to real life examples is more difficult; it does not lend itself as easily as the previous outcome. It is about sketching and interpreting graphs. To sketch them is a matter of learning how, it needs to be taught, and I do not feel that this is of much importance in later life. What is important is once they know how to sketch a graph that they use this insight to interpret already sketched graphs. This can come in handy when interpreting the graphs in a newspaper that indicate the fluctuation of say the rand price.*

Norman's difficulty on seeing the real life application of this outcome and possibilities other than again financial ones is indicative of a shallow understanding of what the outcome can provide for. The curriculum document unequivocally states that, 'Functional relationships pervade our society' (DoE, 2003:12), and then it proceeds to list numerous examples, such as:

- ❖ critique information about functional relationships in media articles such as telephone costs before and after rate changes,
- ❖ calculate relationships in speed, distance and time (DoE, 2003:20),

- draw graphs of: mass against time when on a diet,
- draw graphs of amount of savings against the investment period,
- interpret graphs that: compare the incidence of AIDS over time,
- indicate trends in road fatalities (DoE, 2003:22).

Why Norman was not able to express any of these was somewhat unanticipated, because not only had he claimed to have read the curriculum document and understood it but also many of these examples were articulated in the textbook that he continuously referred to. These examples are relevant and of importance to the lives of many South Africans, the use of which one would expect to be considered both important and more obvious. What may be operative however is that functional relationships were also present in the Mathematics curriculum prior to the FET curriculum, whereas the financial mathematics he is using and refers to in *Learning Outcome One* is new to the curriculum.

This may play a role, for he already has a preconceived idea on how functions are taught which may not have included context. Relinquishing the way he use to teach may be difficult as the reason as to why he should do it differently is not apparent to him, again perhaps due to the limited understanding he has holistically of the curriculum. He may as such be finding it easier to view the topics that are new as a process where context and content are intertwined whereas the old sections he differentiates between teaching the content and then introducing a context to which the mathematics can be applied. This is discontinuous with the curriculum that states that 'context-free algebraic manipulations are not expected' (DoE, 2003:12). What is significant however is that he has recognised, in this outcome, the importance of interpretation which in turn may lead to critical discussion and the possibilities that this in turn may encompass.

Learning Outcome Three, which is 'Space, Shape and Measurement', states that, 'The learner is able to measure using appropriate instruments, to estimate and calculate physical quantities, and to interpret, describe and represent properties of and relationships between 2-dimensional shapes and 3-dimensional objects in a variety of orientations and positions.' (DoE, 2003:12). Norman had the following to say on the significance of this outcome to his students every day lives.

> *It is very significant as it involves working out areas and volumes and doing the necessary conversions between the different units. I found this section easy to teach because we have always taught this type of work. I teach the learners all the formulae and once I have done this I use various examples.*
>
> He continued*:*
>
> *The new section on plans is very interesting, which you will see as we are going to be doing this soon. The pupils learn to sketch floor plans and also top, side and front plans of objects. This can be of use to them in planning their homes or understanding already sketched plans.*

Norman seemed comfortable with teaching this outcome and indicated that he believed it was of significance to his learners and proceeded to furnish two examples of the usefulness of the section. What is worthy of deeper analyses however is the explanation on how he undertakes to teach this section, first by teaching the formulae and then allowing them and showing them how to apply these to different contexts. Although this approach may seem acceptable it is discontinuous with the curriculum document that forwards the following approach (DoE 2003:42):

> The approach that needs to be adopted in developing Mathematical Literacy is to engage with contexts rather than applying Mathematics already learned to the context. Research done internationally and in South Africa confirms this approach for young people as well as for adults.

How will these incongruities with the required approach affect the implementation of the curriculum in terms of the possibilities it has to offer? And even if it does, will Norman ever be aware of this?

These questions are fundamental to this study for if they are not addressed by either Norman himself on an external influence that intervenes on Norman's understanding and beliefs he is more than likely to continue with this approach, and the deep change that is required in his pedagogy may never materialise. Not because Norman may not want to change, but because he does not know what he should be changing towards.

In addition his reply also lacks any reference to the cross-curricular possibilities that this outcome lends itself to. These amongst others include 'design, art, and geography' as stipulated in the curriculum document. Not affording his learners the opportunity to explore the mathematics present in these various fields does limit the engagement of skills that these students are taught. Furthermore, also missing in his response is comment on the aesthetic appreciation of form that this outcome can be utilized to develop and encourage. (DoE, 2003). These finer nuances of this learning outcome seem to have evaded Norman, as they are not reflected in any of his responses. The bearing this has on the implementation pathway the curriculum follows in his actual classroom practice may be that this new curriculum is being taught in a way similar to that of his previous mathematics instructional practice.

The fourth and final outcome of the curriculum is Data Handling, which to a degree like learning outcome one deals with content that is new to senior grade mathematics. This outcome states that,' The learner [be] able to collect, summarize, display and analyze data and to apply knowledge of statistics and probability to communicate, justify, predict and critically interrogate findings and draw conclusions.' (DoE, 2003:12). The possibilities in terms of real life applications that this outcome may afford were explained as follows by Norman:

> *This is like the finance section. It is new to mathematics in Grade 10 and provides the learner with so much that is relevant to their daily lives. Understanding data from various sources and making sense of them is important as it helps the pupils understand a lot of what is written in the newspapers. It also allows them to use probability and see that the chances of winning are not as many as they might think. This is so important for it may prevent them from gambling their hard earned money. It also enables them to understand how numbers can be manipulated in the way that they are represented to give the message that is wanted, like using pie charts in different ways.*

In this reply Norman shows a comparatively deeper understanding of the possibilities that this outcome can provide for. His account is very much aligned to the curriculum document both on a content level and on the deeper core contextual requirements, such as an awareness of data manipulation'. His reference to using the newspaper for examples is topical and rings true with the stated requirement that 'the media frequently provide resources that will assist in making what is currently happening locally, nationally and internationally available to the Mathematical Literacy classroom' (DoE, 2003:42).

Worthy of note is also the relatively deeper understanding of the possibilities that this outcome can offer than the previous two outcomes. This deeper understanding also surfaced with outcome one. Data handling like financial mathematics is new to mathematics grade ten and this may be a reason for his deeper engagement with the curriculum in these two outcomes, in particular with reference to his teaching approach. As new sections, it would be reasonable to assume that he teaches them using the prescriptions of the textbook more closely, than simply relying on past teaching experiences.

By comparing his responses to the curriculum possibilities and learning outcome opportunities it can be argued that Norman has a rather surface level understanding of the curriculum. This limited understanding raises the following issues. Why has Norman not engaged with the curriculum document holistically as seemingly he understands some parts better than others? What are the consequences of his unawareness of his own lack of deep understanding on both his actual classroom practice and on future change? Will his limited understanding play a role in limiting the possibilities that mathematical literacy affords his learners? Will this level of understanding play a role in the problems that he encounters in implementing this curriculum?

6.6.6 Problems

I examine the problems that Norman has encountered during the implementation of mathematical literacy in order to determine if they are of sort to affect the implementation pathway of the mathematical literacy curriculum as intended. In so doing this case study may provide some form of evidence that can inform staff development programs and or educational directives.

In the questionnaire Norman indicated that the curriculum was easy to implement, but examples in the contrast came from an interview during which he expressed several difficulties he was experiencing in implementing the curriculum. I will interpret the contradiction to be nothing more than feeling comfortable during the interview and speaking freely as opposed to answering a questionnaire at the beginning of the study where maybe the boundaries of trust between me the researcher and Norman the respondent had not yet been established. One of the first problem areas he raised was the lack of resources that both he and his students had at their disposal.

6.6.6.1 Resources

Three vignettes from Norman's discussion provide the initial evidence on the problems Norman was experiencing in implementing the new mathematical literacy curriculum:

> *It is not an easy subject to implement in a big class. The pupils are very weak in mathematics and they continuously require individual attention. I cannot give the pupils this attention when there are so many of them (thirty eight), if I do I will not finish the syllabus. I am already behind because I had to go back and re-teach percentages and scientific notation, because the nearly all failed the test on that section. Now I am going a little bit faster so that I can get through the syllabus but the pupils are complaining that I am going to fast. It really is difficult working with only weak pupils in one class. Maths literacy classes should be kept small, at about twenty, and the government should provide for more teachers to teach in schools.*

> He added:

> *It makes it even harder when the pupils do not have textbooks of their own. I know that this subject is new but if the government makes something compulsory surely they should provide the necessary resources, like textbooks for all the pupils. The time wasted in writing the exercises and homework on the board could be used to help the*

pupils that are struggling. I don't know how schools with even less resources cope, at least we have scientific calculators that I can give the pupils at the beginning of a lesson and collect at the end.

Norman concluded:

Also not having unlimited access to the Internet is a big problem. You need this to do research and find new examples so that you are not only using the textbook all the time. The exemplar paper is also from the Internet, from the Thutong website. If I had access I would have found this paper earlier and not learnt about it at the cluster meeting. This paper has been very helpful; it shows you what is expected in a test that makes it easier to understand what exactly you should be teaching.

These extracts from Norman's reply have as their broader theme resources or more accurately the shortage thereof. And although the lack of adequate resources is a serious concern for education in developing countries such as South Africa, such problems are not exclusive to the Mathematical Literacy classroom. Besides which, they have been extensively documented in the extant literature, as outlined in Chapter Two. To discount this broader theme in Norman's response and not to depict it, would however be evading the reality in which Norman believes himself to be operating in.

It would be unlikely however to assume that if these 'problems' were dealt with, that Norman would understand and deliver the curriculum significantly different, particularly with regards to his understanding on how his students ability does not allow him to teach the curriculum as comprehensively as he should be doing.

6.6.6.2 Learner Ability

I continued with this line of inquiry into the problems Norman was experiencing, hoping to glean a deeper understanding on his reference to the weaker learner and the education department (government). Norman explained his earlier reference to his student's ability more expansively:

The pupils doing mathematical literacy think they are stupid, or at least more stupid than their friends who are doing mathematics. So already

> *they are negative and are complaining about how difficult this actually is. Their parents do not understand why they are not passing this easy subject and blame it on the teacher. But they do not understand, maths literacy is difficult, very difficult for the learners doing it, and there will still be pupils who will never pass this. How can they? They have no idea about some basic mathematics concepts. Now they [Education Department] have to compound this problem by asking the pupils to do the maths and also understand long paragraphs of writing. We are not language teachers also, let us focus on the mathematics. That is hard enough, considering that they cannot all do maths.*

It is not clear whether it is the actual learners that feel they are 'stupid' or Norman's perception of their ability. It seems unlikely that a class of thirty-eight learners would express themselves in that way. It is more probable that Norman has formed this opinion of them based on their failing mathematics results from the previous year. Irrespective it is Norman's slant that is of importance for it is this that ultimately intrudes on his actual teaching. For if he believes this to be true how will it impact on what he chooses to teach and what he selects to ignore? Will his beliefs become a justification transposable with the so-called difficulty of the curriculum to justify his learner's achievements? Or, will he accommodate the learners so called weaknesses by adapting his teaching pedagogy and style to suit their learning needs? How does his view assimilate with the assertion that 'all learners can and should do some form of mathematics'?

Norman did at no point specify that any of the outcomes were difficult or included content that was unduly challenging. He did convey that contexts sometimes were long and that the learners experienced difficulty in reading and understanding these. As such his recurrent reference to the difficulty of the curriculum is confounding for once again it is not clear on whether this is his actual view or a reflection of how his learners are experiencing mathematical literacy. Even though language of instruction is a significant point of interest in research on the teaching of mathematics it seems unlikely that in Norman's class this would impinge radically on why the learners were finding the subject difficult, as most of them were fairly proficient in English having received their primary school tuition in this language of instruction.

What may be more likely is that Norman is avoiding introspection of his understanding of the actual teaching required and looking for ways to justify the problems which his learners are encountering, and which ultimately affect him and his teaching practice. His fatalistic attitude of already having judged some of the learner's ability is also striking as it exemplifies his view with reference to the previously mentioned assertion. This is considerable for if he believes that not all students can learn mathematics he is making this obstacle a function of the students learning rather than a function of teaching. As such it exonerates him from taking responsibility for his students learning. Being a mandatory curriculum for those not taking mathematics this becomes pertinent for the purpose of this curriculum, which includes empowering all students with skills to access mathematics in everyday contexts.

6.6.6.3 Mandatory Curriculum

In a conversation with Norman I asked him if these problems he was finding in implementing the mathematical literacy curriculum had caused any stress or anxiety for him. It was the first time that Norman appeared to show some form of discomfort with a question. Listening to what he had to say somewhat made this unease that I was sensing clearer:

> *I do not know if I would call it stress, maybe anger, anger directed to the powers that be that made this curriculum compulsory. They do not understand what we teachers are faced with, they make a decision that will allow the education departments statistics to look good, and avoid coming into the actual classrooms and really seeing what is happening. We have no choice; it is compulsory to offer mathematical literacy. If they came into the classroom they would realize that the pupils are struggling with this even more than they were with standard grade mathematics, and that they do not even have textbooks that can help them. In the meantime it is we the teachers who get a bad name with the pupils and their parents.*
>
> Uninterrupted he added:
>
> *As for anxiety, not really. I know that I am teaching properly, the exemplar paper is proof of this. The pupils who listened and did their*

> *homework would have no problem answering the sections from this that we have already covered. This year's group is also not really in danger of failing when they get to Matric (Grade 12). We have heard that for the first two years the education department will not fail anybody in Mathematical Literacy in Matric because it is such a new subject. So until then we can relax and find our feet. It will only be with the Grade 10's of 2008 that we will have to worry about them failing matric. Perhaps until then they will change the syllabus and make it easier, who knows they may even go back to standard grade mathematics. Or even realize that they cannot make mathematics compulsory for everybody. Why is Science not compulsory, because they know not everybody can do Science? How is Mathematics any different?*

Norman's anger is directed at the education department which he blames for the implementation problems he is faced with. These include a difficult curriculum, a non-negotiable mandatory curriculum and a considerable lack of resources, all of which he places at the door of the Department of Education. He is also in possession of information on how learners will be promoted in Mathematical Literacy once they reach Grade 12, which appears to put his mind at ease somewhat, with his current group of learners. This information that Norman has is however unofficial and not in alignment with the promotion requirements stipulated in official promotion documentation[18].

I attempted to clarify this discrepancy by contacting several officials in the education department were I was twice referred back to the official promotion document I had in my possession. Despite this I found the rumor about all learners being promoted in the first year of writing the grade twelve mathematical literacy examinations to be out of the ordinary as there was no reason for it to be in existence unless a person in the know somehow started it. On my third attempt, during a telephonic interview with a prominent member of the South African Mathematics teaching community, my suspicions were confirmed when the interviewee concurred that this was the thinking in the higher echelons of the Department of Education. How this discussion had got out and how it reached a small town on the East Rand remained a mystery. What is clear however is that

[18] During the time of the study it was mandatory to pass Mathematical Literacy as a subject for promotion purposes in Grades 10-12.Subsequently,in 2007,this requirement was changed and although doing Mathematics or Mathematical Literacy remains compulsory, a pass is not required in either for promotion in Grades 10 -12.

this information was explicitly impacting on Norman's motivation to drive his students' success which in turn played a role on how the curriculum was unfolding in Norman's classroom.

It may even be argued that this single piece of information contributed to Norman's surface level understanding of the curriculum as it prevented him from further exploring the curriculum by denying tension and anxiety to be felt by him as a result over his students' low achievements. If a change is required in his instructional practice, this may not be pursued if he believes that ultimately his students will pass Mathematical Literacy because the Education Department needs to right the wrong and difficult standard of the curriculum.

Furthermore, Norman's constant dependence on the exemplar paper suggests that the pre-1994 struggle idealism of a teacher constructing their own curricular ideas, from guiding was just that-political idealism. Why did Norman respond this way? With reference to the official support Norman had received was enough being done to assist Norman with the knowledge and skills required for said construction?

The above report and analyses account for the reported problems that Norman was faced with relating to the implementation of the curriculum. In the curriculum document there is a conspicuous absence of any guidelines that assists educators working in resource-deprived conditions or with learners that have acquired mathematical difficulties throughout their schooling.

These two conditions are not inimitable to Norman's teaching environment and pervade many South African classrooms .Why this is not addressed in the curriculum then becomes a point of contention. It is one thing for the document to say that the curriculum addresses social justice and another for it to explain how this is to be done in the actual classroom by the teacher. Granted, the workshop that Norman did attend which was provided for by the Department of Education did cover an area described as 'The Mathematical Literacy Learner', however the timing may have been too soon and

Norman may not have, at that early stage been able to identify with the problems that he was to later encounter. This speaks to such staff development programs that need not only take into account what needs to be covered but also perhaps when it needs to be covered. Educator responsiveness is crucial to the learning process and to change, and an overload of information at the onset of an implementation phase may work against a deep realization of this.

The exploration of Norman's understanding of the Mathematical Literacy curriculum within the framework of the first research question revealed confusion, anger and a generally thin understanding of the curriculum document. How this cluster of understanding and emotion informed Norman's practice will be explored through the framing of the second research question, which follows in the next section of this Chapter.

6.7 How does Norman proceed to implement the mathematical literacy curriculum in his classroom?

In this section I describe and explore Norman's instructional practice as a response to the research question; how do teachers proceed to implement the mathematical literacy curriculum in their classrooms? I compare the claims he makes with regards his instructional practice to both his beliefs and the curriculum document, and then further against the observed classroom practice. As explained in Chapter Four, the data points drawn upon to construct the portrayed findings include the Questionnaires (Schedules A&B), Classroom observation protocol (Schedule E), Document analysis schedule (Schedule F), casual conversations, and notes from the Researchers journal (Schedule J).

The casual conversations were not included in the original design but as the draft of the write up of the findings occurred at the same time as the actual research I found that some of the responses from the questionnaire warranted further discussion to further clarify and identify the emergent themes. These conversations were normally brief and mainly revolved around one or two of Norman's responses on the questionnaire which I asked him to further explain.

I begin this section with a discussion of Norman's claimed teaching practice and the alignment this has with the curriculum document.

6.7.1 Claimed Instructional Practice

Establishing how Norman understood his instructional practice in his mathematical literacy class, and his beliefs on the traits that an effective mathematical literacy educator espouses, was an important starting point to this line of inquiry. The intention of which was to offer up the framework in which Norman understood he had to work in.

Norman wrote that the teaching of mathematical literacy was different to that of teaching mathematics as the former included using contexts and 'everyday maths problems' whereas this was not a requirement in the latter. He further indicated that his understanding of the nature of teaching mathematics had not changed since implementing the new curriculum with the exception of using contexts. He strongly agreed that the teaching of mathematical literacy was an opportunity for educators to redefine their thinking about the nature and teaching of mathematics, that mathematical literacy teaching should delay formal methods (algorithms) in favor of extended opportunities to engage mathematics in diverse contexts, and agreed that instructional practice should include issues related to human rights, environmental and social justice as well as the valuing of indigenous knowledge systems. He disagreed that the teaching of mathematical literacy should support only lower order skills and knowledge and also disagreed that teaching allows for no real abstract thinking only practical application.

As for the traits of an effective mathematical literacy educator, Norman strongly agreed that the educators should be confident in their own knowledge and agreed that they should posses the following traits and behaviors:

- have high but realistic expectations of all learners

- promote and value learner effort
- focus on key mathematical ideas
- modify teaching as a result of lesson reflection
- believe that mathematical teaching and learning should be enjoyable
- vary their roles as teachers
- connect mathematics ideas to various contexts
- make the mathematical focus clear to the learners
- use teachable moments as they occur

He also further noted that educators teaching Mathematical Literacy should be qualified and have some form of tertiary training in mathematics.

Contexts and the use thereof was once again the only point around which Norman believed teaching practice should change. His beliefs and perceptions of what mathematical literacy instruction should be as well as the effective traits of mathematical literacy teachers were on the most part continuous with the requirements of the curriculum and the literature on effective mathematical literacy teachers. Did his beliefs reflect his claimed practice?

Norman indicated that his current teaching practice <u>mirrored</u> the following statements; engages with real-world problems, uses various contexts, affords high levels of numeric skills, lessons engaged learners both critically and creatively and addressed issues of social justice. He admitted that there was <u>room for improvement</u>, in integrating lessons with other disciplines and making his teaching sensitive to indigenous knowledge systems. Charts, tables, data from media, newspaper articles and debates were tools and techniques that he said he <u>often</u> used in his teaching practice. Whereas textbooks and scientific calculators were <u>always</u> used, but no other technology was ever used. Reflection and learner chosen contexts were also <u>often</u> used.

Collective analyses suggest that Norman's beliefs and claims are generally well aligned not only to each other but also to the curriculum document. Two points worth mentioning that seem to be at variance include, one the non-use of technology other than scientific calculators, which will be taken to be as a result of the lack of resources in the school, and two that there is a discrepancy on what his actual expectations of his students are. For although he claims that these should be 'realistic but high', Norman's 'realistic', as he has previously stated, includes only basic mathematics knowledge. As this is only one part of the curriculum, what he chooses to deliver to his students is restricted by what he believes that they can achieve and understand. This affects the implementation of the curriculum, as delivery of basic mathematics and knowledge is not the only curriculum requirement. Despite these two observations, there is a sense that Norman's instructional practice has embraced the curriculum as intended to a considerable degree.

6.7.2 Observed Instructional Practice

As indicated, Norman's claims and beliefs line up with several of the provisions made by the new curriculum. The classroom observation will provide the direct evidence that can be used to corroborate, refute or augment this evidence further .By inquiring deeper into the dynamics of his classroom practice I will also explore how Norman's understanding of the curriculum has effected his practice. In this way I can assemble a more holistic representation, which I hope will grant a preliminary understanding of the relationship between the mathematical literacy curriculum and Norman's instructional practice.

I observed lessons in Norman's classroom over a period of six weeks. Five continuously starting in the last week of July 2006 (Schedule E), and one follow up week in mid-October 2006.In total nineteen lessons were observed, each lasting one-hour. The class observed was the Grade 10C Mathematical Literacy class at East Rand High School. I begin the account with a description of the first lesson observed.

6.7.2.1 Observed Lesson: One

Learners started arriving to the lesson ten minutes before the lesson was scheduled to start, with the last learner arriving five minutes after the scheduled starting time. Norman explained that this happens often as the different lessons allow the learners out at various times especially if they are busy been assessed. Once all the learners had arrived Norman asked for silence and then proceeded to greet them as well as to introduce me. Barring a glare or two my presence was surprisingly ignored and the lesson began.

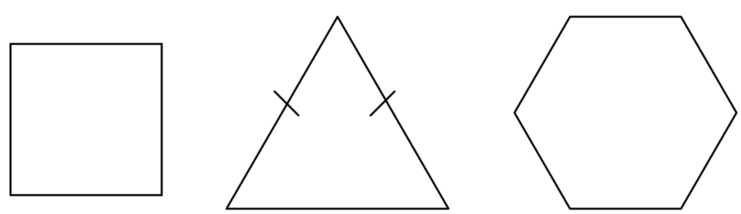
Norman asked the learners if they had done their homework to which they unanimously responded to with a no, justifying themselves by complaining that they did not have time to copy it down from the board the previous Friday. Norman began his lesson by writing up the days work on the chalkboard. The lesson is given below in its entirety so as to begin to establish his instructional practice and hence glean his understanding of teaching for mathematical literacy.

Symmetry

Question 1) Make cuttings and drawings of a daisy with 4 circular petals and an oval center and a butterfly with 2 similar wings attached to an oval elongated body with a circular head and 2 straight feelers protruding from the top of its head. Find the number of lines of symmetry for each drawing.

Question 2) How many lines of symmetry do the following have?

A square, an isosceles triangle and a regular hexagon.



Mr. Mhuka*: With regards to question one, marks will also be allocated for the diagrams drawn. Remember lines of symmetry are easiest of all. Once you have drawn in your lines of symmetry fold your drawing on these lines and see that they work.*

The learners then proceeded to copy the questions from the board and Norman went and sat at his desk. The next twenty-minutes were taken up by Norman continuously asking the class to stop talking and calling individuals to his desk and recording their names for been disruptive. The one learner was told that this is his third infringement and was sent to the Grade Controller who in turn would meet out the necessary sanction. Most of the noise was emanating from learners asking and calling for the one pair of scissors that was been used to make the cuttings.

Another source of disruption was that the learners did not want to cut up the drawings in their books and started to look for loose paper, which then further wasted time for they redrew all the diagrams on the loose paper, most of them tracing their original butterfly and daisy. The last ten minutes of the lesson were used to mark the lines of symmetry for the butterfly and the daisy.

Norman drew one line down the center of the butterfly and four lines of symmetry for the daisy. He told the learners to mark their work and asked them if they had any problems. Not one learner indicated that they needed anything explained. By now the lesson had come to and end and the learners were once again asked to finish question two for homework. The interview that followed this lesson indicated that Norman was mostly satisfied by the lesson and what his students had learnt.

> Interviewer: *What was the purpose of this lesson?*
>
> Norman: *We have been doing symmetry for over a week now and this was a short assignment I gave the pupils to do over the weekend. Unfortunately they did not finish taking down the questions and we had to continue with it today. The cutting out is important because it helps them to see how the lines of symmetry work. In the past, the examples used would have only been of shapes, the square, etc. But now we are also using examples of flowers and butterflies so that they can see the symmetry in nature.*
>
> Interviewer: *In your view was this a successful lesson?*
>
> Norman: *Yes, definitely! The pupils seemed to enjoy it and also learn from it.*
>
> Interviewer: *Do you believe that the pupils acquired the skills and knowledge you expected of them before the lesson?*

> Norman: *Yes. They have understood symmetry and have learnt to test the lines of symmetry by folding their cuttings on these lines and seeing that the two sides line up with each other.*
>
> Interviewer: *In future would you do anything differently?*
>
> Norman: *I would give the learners, photocopies of the drawings because this way we wasted a lot of time.*

Lesson one revealed that several of the claims that Norman made about his instructional practice actually took place. He engaged the learners creatively, used various contexts and his cuttings and folding afforded the development of higher order skills. In the post-lesson interview his reply that 'the pupils seemed to enjoy' the lesson also rang true with his belief that mathematical literacy lessons must be enjoyable.

Comparison to the curriculum document however reveals that his practice is only a reflection of the surface features of the document. The assessment standard dealing with symmetry in the curriculum document states (DoE, 2003:28):

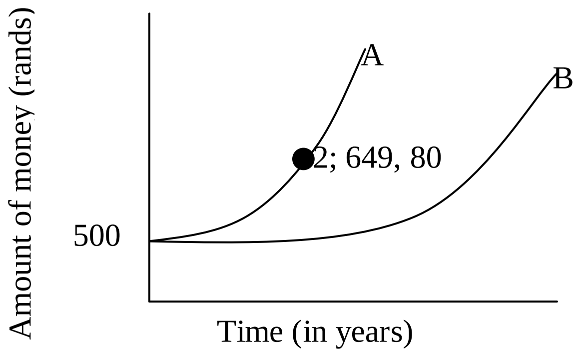
> We know this when the learner is able to:
> Recognize, visualize, describe and compare properties of geometrical plane figures in natural and cultural forms.
>
> For Example:
>
> - ❖ Use the concepts of tessellation and symmetry in describing tiling, Zulu beadwork and other artifacts.

Taking the natural form, Norman had dealt with the visualizing and perhaps the recognizing but at no stage did the discussion include 'comparison' or 'description'. The use of symmetry and its application in everyday contexts was substituted with the use of two pictures that by no means represent the intentions of the curriculum. This surface level use of a picture to represent context is further verification of his lack of a deep ownership of teaching 'mathematics in context'. Ignoring a discussion on the aesthetic value and application symmetry has is further evidence of his limited understanding, especially when one considers his passion for art. This thin and disconnected level of understanding with the curriculum continued to surface in most of Norman's lessons.

6.7.2.2 Observed Lesson: Five

The normal ritual of learners arriving over a period of approximately ten minutes, being greeted and finally settling done was followed once again during this lesson. Two lessons earlier Norman had started using the compound interest formulae and this was the first time, in this section of work, that the example on the board was not only numerical calculations. The problem Norman posed to his students was the following:

> Below are two graphs. Graph A represents the amount of money Andile has in the bank in relation to the number of years he has invested it for. Graph B represents the amount of money Bhavini has in the bank in relation to the number of years she has it invested for. Both Andile and Bhavini are earning compound interest:



> a. How much money did Andile and Bhavinin invest originally?
> b. Who is getting the higher rate of interest?
> c. Calculate the interest rate Andile is getting

The learners were then given time to copy the question down and were asked to work in groups and come up with the answers. In the next twenty minutes the learners seemed to finish as the noise level had once again climbed considerably. Norman returned from his desk to the chalkboard and asked the learners for the answers. Shouting out of five hundred rand and Andile confirmed that the learners were able to use the graph to answer the first two questions correctly. However calculating the interest rate seemed a much greater problem.

After an explanation from Norman that the initial amount of five hundred rand had grown to six hundred and forty nine rand and eighty cents in two years he wrote the equation that needed to be solved on the board. What happened next is evidence of the difficulties that under-resourced classrooms can be faced with. The learners required calculators to solve the equation further which Norman had forgotten to hand out at the start of the lesson as he had done during the previous two lessons. The learners started complaining that now as they were seated they could not easily move around and that the calculators should be passed from the front to the back. Norman usually hands these out at the beginning of the lesson to learners who do not have a scientific calculator of their own as they enter the classroom. The learner than signs next to his or her name on a class register and then when leaving they return the calculator and Norman ticks against the name. Norman did not want to pass the calculators back during this incident, as he feared that he would not have a record of who actually took one. Having decided against handing out the calculators Norman verbally explained to them how the calculation should be done and wrote the answer on the board. They were told that they would have an opportunity the next day to do the calculation themselves. This brought the lesson to a close. Once again Norman was pleased with his instructional practice of the day, barring the incident with the calculators.

> Interviewer: *What was the purpose of this lesson?*
>
> Norman: *To show the learners how this information can be used in a different context.*
>
> Interviewer: *In your view was this a successful lesson?*
>
> Norman: *Yes, other than the chaos with the calculators, which was very disturbing?*
>
> Interviewer: *Do you believe that the pupils acquired the skills and knowledge you expected of them before the lesson?*
>
> Norman: *I am sure that they can do the calculator work; anyway they will get another opportunity tomorrow. Analyzing the graph, yes. They managed to interpret the information for the first two questions nicely.*
>
> Interviewer: *In future would you do anything differently?*

> Norman: *I will remember to hand out the calculators at the beginning of the lesson. The rest was fine.*

None of the claims that Norman had made with respect to teaching compound interest had materialised over the three lessons that he spend on teaching the concept, which included the lesson above. Compound interest was introduced using the formula, which was then manipulated to solve various numeric examples for a period of two one-hour lessons, and then the section was concluded with the lesson illustrated above. Its use in real life context was a brief explanation from Norman during the first lesson when he said the following, "this is the formulae that banks use to calculate the interest on the money you deposit, or vice versa the interest on the money you owe them".

The attempt at using some form of context on day three was neither authentic or of relevance to the learners lives and was also devoid of any relevant discussion other than tackling the mathematics itself. The curriculum requirement, which includes the application of 'mathematical knowledge and skills to plan personal finances so as to enable effective participation in the economy' (DoE, 2003:26) was once again met superficially at best. The content dealt with was 'naked' of relevant context.

Similar observations became a pattern over the next eleven lessons and I became pleasantly surprised when during observed lesson number fourteen Norman announced to the class that the next days lesson would be different and they must arrive on time as otherwise they would find the classroom empty. This did not seem to inspire the learners in any way that continuously complained about the speed of the lessons and the difficulty. I was however intrigued to see what Norman had in store for his next lesson- Observed Lesson Fifteen.

6.7.2.3 Observed Lesson: Fifteen

Despite their lack of enthusiasm on the previous day the learners somehow managed to arrive relatively together and a couple of minutes before the designated start of the lesson. Once they were all at Normans' classroom, he handed them each a piece of paper and asked them not to unpack anything other than a ruler and a pencil. The class was then lead out to the field and Norman explained to them that they were going to spend this lesson drawing and measuring one of the sport fields. They were told that it was a floor plan and that they should sketch it and indicate on it the various measurements. He had four measuring tapes and as such asked them to divide themselves into a similar number of groups. The learners spent the rest of the lesson taking the measurements and sketching the plans, some of the hockey field and some of the athletics track. At the end of the lesson they were told to draw up their plans neatly for homework and to bring these to school for marking the next day.

This lesson was the only lesson that I observed over the entire research period that did not begin with homework being marked or an explanation given of some mathematics formulae or concept. I was not yet quite sure as to what the purpose of the lesson was as Norman was unable to give a post lesson interview that day, but it certainly was aligned to the curriculum in terms of favoring process over content. It was such a promising start to a new section of work that as the follow up lesson will show ultimately delivered the curriculum intentions on a different and a deeper level than any of the other lessons I had observed thus far, despite the fact that it still lacked the depth of what was required by the curriculum document in terms of 'plans'. The curriculum states (DoE, 2003:26):

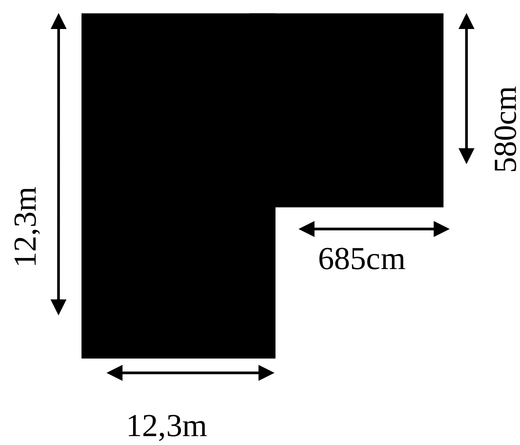
> Draw and interpret scale drawings of plans to represent and identify views.
>
> For example:
>
> - ❖ Draw and interpret top, front and side views or elevations on a plan

6.7.2.4 Observed Lesson: Sixteen

Norman began this lesson by asking for the previous day's homework to be handed in. From the thirty-six learners present that day eleven learners handed the previous days work in. The excuse for the rest seemed to be a unanimous "we did not understand what to do". Norman accepted this and gave them another two days extension explaining that after today's lesson they would know exactly what to do." After all", Norman announced, “this is the maths of oranges and bananas ". He then turned his back to the class and put up the days lesson. The connection to the previous days work was left unexplained.

Look at the plan of a plot and house on the left.

a. Convert the lengths of the boundary of the plot to centimeters.
b. Calculate the perimeter of the plot.
c. Calculate the cost to build a wall that costs R180 per meter around the plot.
d. Calculate the area of the house in square meters.
e. Convert the area to square centimetres.
f. It costs R2500 per square metre to build a house. Calculate the cost to build the house.



Instead of going to sit behind his desk, this time Norman remained at the board and asked the learners to copy down the plan only and not the questions. Having given them time for this he continued by asking the learners how they would solve the very first question. Once again the noise level rose but soon an order was established between learners and educator. The class gave answers and ideas and Norman either used these as they were given or explained how they had to be corrected. Having worked through all the questions together the learners were finally told to copy down the questions. This change in approach, Norman acknowledged in the post-lesson interview had made a difference.

> Interviewer: *What was the purpose of this lesson?*
>
> Norman: *To allow learners to apply the knowledge they have learnt to a context relevant to their everyday lives.*
> Interviewer: *In your view was this a successful lesson? Why?*
>
> Norman: *Yes. It was different and the pupils did not seem bored. It also kept the noise levels down. Discipline is a problem with weak pupils, because they do not understand they loose focus and start to talk, which then disrupts the entire class.*
>
> Interviewer: *Do you believe that the pupils acquired the skills and knowledge you expected of them before the lesson?*
>
> Norman: *I really think so. When they hand in the plans from the day on the fields I will be able to see if this worked, but at least in class they seemed to understand what the plan was about.*
>
> Interviewer: *In future would you do anything differently?*
>
> Norman: *I am not sure; I think this lesson worked well.*

This interaction of allowing and using student ideas and answers was a unique feature of this particular lesson, and as explained by Norman was an attempt to control the disruptive noise levels. However, his awareness that the pupils in his class became talkative because they did not understand the lesson raised three important questions. Firstly, why did Norman not establish who these 'weak' students were and offer them assistance with the task of the day? Secondly, did his beliefs on what they could and could not do, prevent him from trying to assist them? And thirdly, if this curriculum was meant to provide for knowledge and skills to all students who do not do the subject of mathematics did Norman's behavior affect the implementation of such a mandatory curriculum intended for all?

Furthermore, even though Norman did not provide an explanation for the link between the two lessons explicitly, and the floor plan was not a scale drawing, taken together the above two lessons had managed to successfully integrate several curriculum requirements. The learners had been shown how to 'convert units of measurement within the metric system', used some of their pre-knowledge in revising Area and Perimeter, calculated cost within a context, and were exposed to floor plans both in the sketching of a real world example, and in recognizing a given plan. Having succeeded in doing this the lesson still did not match up to the curriculum document with the required depth as described before this lesson depiction, in that it did not allow for interpretation and description of the plans. The focus was once again on the mathematics required in measurement and calculation.

Another point of significance that arose out of this lesson was the comment Norman made to the class on mathematical literacy being the 'mathematics of oranges and bananas'. During the interviews Norman had repeatedly said that mathematical literacy was too difficult and yet in this lesson his comment was evidence that he believed this curriculum to be a mathematics curriculum that was open to ridicule. Did this perception he had of the curriculum contribute towards why Norman did not want to be known as the mathematical literacy teacher? For if he believes that the mathematics in this curriculum can be ridiculed does he believe that teaching it opens him up to similar derision?

Additionally, it shows that Norman considers this curriculum as a mathematics curriculum through his constant comparison to the core mathematics content. He has not understood this new curriculum as something distinctly different from the mathematics that he is used to teaching. That is, with a purpose and nature that is dissimilar to that of the core mathematics curriculum and also past mathematics curricula, in that the emphasis is not on learning difficult mathematics but being able to deal with and comprehend contexts in which mathematics is required.

Another of Norman's claims was that other than using context he had not needed to change his instructional practice with regards to teaching mathematical literacy. To understand this claim further I decided to observe some of his lessons in the other subjects that he taught. I sat in on four of his Grade 10 Mathematics classes, three Grade 11 Mathematics classes and four Grade 10 Life Orientation lessons.

The grades ten and eleven Mathematics lessons afforded the most insight, for during these lessons it became evident that his instructional practice did not vary in any considerable way between how he taught mathematics and how he taught mathematical literacy. Not even in the use of context, which was as artificially used in the grade ten mathematics class as in the mathematical literacy class- as a 'dress-up' to the content, either through the use of a picture or some form of word problem. This provides for further evidence for the surface understanding that Norman had of the curriculum in terms of teaching 'mathematics in context'.

The pattern of marking homework, using the textbook to put up a worked example, discuss it and then give the learners similar problems to tackle was also repeated in his instructional practice in the mathematics classes and was only broken in the observed Life Orientation lessons. Here there was less writing and a significant amount of discussion. Views, expressions and debates were commonplace and the learners felt free to express and challenge each other and Norman. His ability to engage with a class was evident in these lessons; the question that arises is why did he not encourage this in his mathematical literacy classroom? Was this because of his surface level understanding of the nature of mathematical literacy, and his understanding that the mathematics should be the focus?

Synthesis of the observations of the nineteen Mathematical Literacy lessons result in the following findings that are of significance both to his claims and the curriculum document:

- teaching does not support student engagement with a variety of mathematically rich contexts;
- use of contexts are either not authentic or are textbook dependent;

- teaching does not support guided discovery of mathematical rules and procedures;
- students are not encouraged to seek understanding;
- mathematical life skills taught are at a surface level;
- no reflection or discussion on solutions occurs;
- instructional expectations of learners are low;
- teaching does not encourage critical engagement with regard to mathematical arguments;
- instructional practice is teacher-centered;
- order of daily lessons is entrenched;
- content and context are independent events.

These findings reveal significant discontinuities not only between the curriculum document and Normans' instructional practice but also between his practice and his claims. The lack of congruence between the curriculum document and Norman's instructional practice may be evident to the researcher and the reader but does not seem to be evident to Norman. This then becomes a point of discussion, for if Norman's instructional status quo is not recognized by him how will the required changes come about? Who will address Norman's depth of understanding and confusion with him? What dialogue or action is required to bring about the necessary understanding and hence change?

The learning material of the students was also looked at in order to ascertain further substantiation for the emerging understanding that the previous data points provided for.

6.7.3 Learner Work Books

Throughout the observation period, when time and circumstances permitted I scrutinized the workbooks of the learners who without fail had them with them in all the observed lessons. The majority was neat and had the lesson of the previous day copied out. What was striking is that the solutions were nearly all-identical, evidence that the learners were not attempting the problems set on their own but copying the solutions from the board.

There was no evidence of any hand outs in terms of worksheets and the like, and other than the two tests that the learners had stuck in their books, the learner work books were a reflection of the days chalk board lesson and the answers given. This workbook record of the lessons showed that, lessons did not have an explicit purpose other than the teaching of mathematical formulae and algorithms, did not provide for opportunities of real life application, had a limited and forged use of context with many having none, and lacked a strong correlation with the Critical and the Developmental Outcomes of the curriculum document.

There was also no significant difference, with respect to 'teaching mathematics in context' between the work done earlier on in the year and that observed during the research period. This was indicative of an instructional practice that was not attempting any further change, possibly because the change agent did not know that change was required.

What Norman did know that he should be doing differently was to present his students with assessment tasks other than tests. However, as he considered that this took time away from his actual teaching of mathematical content he opted to delay it for a year.

6.7.4 Learner Portfolios

There was no record of any portfolio files having been kept or the requisite tasks for these other than summative testing. Norman reasoned this by explaining that he would begin with this in the following year so as to give himself time with his students to focus and build their basic mathematical knowledge.

As portfolio work is integral to the teaching process in that it provides various methods for instructional and assessment purposes his reasoning was once again not connected to the requirements of the curriculum document. He viewed the alternate tasks[19] as tasks that would take time away from his teaching of mathematics, and did not understand that this could be achieved through the use of tasks other than textbook exercises.

This focus on building the basics prevented him from providing his students with opportunities to engage with mathematics in a wider range of contexts, which is one of the main purposes of the curriculum. Why he chose to do this is twofold. Firstly, Norman did not have a deep understanding of the nature of mathematical literacy, as he believed that it was a mathematics curriculum with lower order mathematics concepts. And, secondly, he wanted to teach mathematics because he valued mathematics, as he knew it, and valued himself for having the ability to teach it. This is what he was trained to teach, what he wanted to teach, and most significantly what he believed was important to teach.

6.7.5 Tests

The learners had two tests stuck in their workbooks, which had several questions with no context but an overwhelming majority that did make use of real life applications. I will depict a segment of one of the tests below in order to raise the following question? Why is there a deeper understanding of the nature of mathematical literacy in Norman's summative assessment practice than in his instructional practice?

Grade 10
Mathematical Literacy
Date: 3 March 2006
Time: 1hour
Total: 60 marks

…
Question 7
7.1 Thabo earns a salary of R400 per month. He pays 22% PAYE (tax), 5% for medical aid and 6% for pension fund contributions. What actual amount in rands does he pay for in?
a) PAYE (2)

[19] These include; interviews, case studies, debates, assignments, research tasks and projects (DoE, 2005).

b) Medical Aid (2)
c) Pension Fund (2)
7.2 What is his net monthly income after deductions? (2)

Question 8
The workers in the mining industry agree to an annual wage increase of 7%. If a miner was earning R3 500 per month, what will he earn after the increase? [3]

Question 9
The label on a bottle of milk says that the concentration of fat in the milk is 2%. How many ml of fat will there be in a 250 ml glass of milk? [3]

Question 10
Which is the better value for money?

250g of coffee for R17, 49 or 600g of coffee for R37, 77 [2]

Question 11
An advertisement in a clothing store says:

a) 1/5 off regular price items. What can you expect to pay for a pair of shoes that normally costs R780?
b) 25% off our regular price of any items. What is the regular price of a jacket that now costs R56? (3)

The answer is simple, because Norman uses the textbook that his students do not have to take his tests from. If Norman's assessment practice was an integral part of his instructional practice this answer would not be important. But as Norman practices the two as separate events further explanation to this will be pursued in response to the third research question, which forms the final part of this case study.

6.8 Why does Norman implement the Mathematical Literacy curriculum in the way that he does?

Having explored Norman's perceptions and understanding of the curriculum as well as his claims and actual instructional practice I will now deal with the third research question, namely, why do teachers implement this curriculum in the ways they do? In other words, what explains the implementation pathways followed by the mathematical literacy curriculum in real classroom contexts?

The evidence for the response to this research question is obtained form five data points namely the, Interview Schedules (Schedule C&D), Questionnaire Schedule (Schedule B), Document Analysis (Schedule F) and the Researchers Journal (J).

6.8.1 Educator Documents and Records

Norman's arsenal for mathematical literacy included the curriculum document, three mathematical literacy textbooks, weekly schedules, notes from the workshop and the exemplar paper. The curriculum document and the three textbooks were given to Norman at the beginning of the year by his head of department, the workshop notes he acquired later on in the year and the exemplar paper seven months into the year from one of his colleagues.

6.8.1.1 Text Books

Norman used one of the three textbooks he had in his possession on a daily basis. The other two were used to set the tests and examinations for the year. His decision on which textbook to use was indiscriminate and he could not recall why he had decided to use the particular one he did for classroom instruction and the other two for assessment. His weekly modus operandi in planning for his lessons was to refer to the work schedule at the front of the textbook, adapt this were necessary in terms of time allocated to a particular outcome or learning unit and then select several examples from the textbook as units of teaching. Selection of what was to be taught was not normally pre-planned and the examples used were more often than not based on decisions made during the teaching of a lesson. He explained his selection process as follows:

> *I look for the easy examples first, the ones that do not have a lot of reading, only basic mathematics, and I begin with these. Then I select a slightly harder one with maths and reading and continue doing this until I have worked through several levels of difficulty. It is important that I do easy examples and difficult ones because not all the pupils have the same ability. In this way there is something for all of them*.

What is striking in this comment is that although it appears that Norman's practice caters for individual learners needs he had somehow decided that the questions that had less reading were the easier questions. In other words, teaching mathematics without context is what he believed needed to be delivered to the pupils with less mathematics ability. Adding reading he saw as synonymous with adding context and further understood this as developing the level of difficulty of a question. How he had arrived at this which is a perception misaligned with the curriculum document was undisclosed and can only be interpreted to be part of the thin level of understanding he had for what it meant to teach 'mathematics in context'. It also further raised the question that if he believed that most of his students were weak in mathematics, which he continuously stated, would this prevent him from teaching in context, as he believed this to be a higher order skill which his pupils should or could not learn?

The two other textbooks were used to set the assessment tasks to date. The questions in the test that I presented earlier were all taken from these two textbooks with the mark allocation being the only contribution that Norman had made. What Norman understood assessment to include was then not a reflection of his knowledge and understanding but that of the authors of the textbooks. A concession can be made that the actual examples chosen are a reflection of his understanding of what was required, however the process showed his lack of ownership of the curriculum, which ultimately impacted on the implementation pathway that mathematical literacy followed in his actual classroom. Ownership of the curriculum or the lack thereof was evident in Norman's following comment:

> *The textbooks are really good and the work has already been done. It is quicker and easier for me to use these examples than setting a test from scratch by myself. Then I would have to worry if I was doing it correctly,*

> *if I had set it at the right level. This way, I know that what I am testing is what is required. The pupils do not have access to these books so I am not worried that they will have seen these questions before.*

Observations from Norman's other classes further showed the use of the textbook to be the predominant source of reference in those classrooms as well. This support demonstrates that Norman proceeded to implement mathematical literacy as he would any other mathematics curriculum that is, by using the instructional material that was ingrained in his practice.

What seemed to have resulted in the textbook becoming the frontrunner reference document is that it not only required the least effort from Norman, but also more importantly provided him with security that what he was doing was correct. This is important because Norman is a hard working teacher, and even though he admits it is quicker and easier to use the textbook he is also concerned with knowing that what he is doing is correct. His reliance on the textbook over the curriculum document, that is his reliance on the textbook author's interpretation of the curriculum over his own, can be ascribed to his experience with textbooks of the past-which had served him well.

6.8.1.2 Mathematical Literacy Curriculum

In the questionnaire Norman indicated that he understood the curriculum document to a large extent. This was refuted by the evidence from the other data points that showed that he had only read parts of one of the chapters of the entire document, namely Chapter 3: Learning Outcomes Assessment Standards, Content and Context. He had referred to this in the beginning of the year for several weeks in order to draw up the weekly schedule that his head of department had requested until he realized that an example of a weekly schedule was also in the textbook. He then never saw the need to refer back to the curriculum as he felt that the textbook had been based on the curriculum and was more than a sufficient reference point.

He did however keep a copy of the curriculum on the book case behind his desk incase the need arose for him to further use it. Why Norman gave preference to the textbook over the curriculum document seems to be based on his entrenched classroom practice of seventeen years. Textbook use dominated his instructional practice in the past, evidently dominated his current practice, and there was no indication that it would not dominate his future instructional practice. The significance of this is that he had never read the curriculum document as a whole and other than realizing that he had to use context in his mathematics teaching continued with the pedagogical style he had always used to date. Furthermore his beliefs with regards to the nature of teaching mathematical literacy also remained unchallenged, since his reading and ultimate understanding of the curriculum was on a surface and disconnected level.

The implementation pathway that mathematical literacy followed in his class was thus mostly based on beliefs and understandings Norman always held, and partly on the textbook interpretation of the curriculum document. The curriculum document provides comprehensive guidelines on the purpose, scope and possibilities of mathematical literacy, however even if read, without appropriate support and explanation it does not imply that it will be understood as intended. Such support could be provided for in teacher workshops, one of which Norman had attended earlier on in the year.

6.8.1.3 Workshop Notes

As discussed earlier, Norman had attended a workshop on mathematical literacy, which he at the time found to be of little relevance. His views were based on the assumption that if you can do the mathematics in the new curriculum you did not require undergoing staff development in the subject. Norman assured me that all he had to do differently was to ensure that he was using contexts in his teaching of mathematics. Norman further admitted that he had never again referred to any of these notes.

Analysis of these notes revealed several sections that may have been useful to Norman in the difficulties he was experiencing with teaching the 'weaker mathematics learners'.

However he did not refer to these, because his focus was the actual mathematics that he believed he knew and did not need to refer to workshop notes to be taught. This narrow approach to teaching can be assumed to be based on years of experiencing similar teaching practices both in how he was taught and how he had taught to date.

Having used the word context in so many of his responses to my questions I wondered how he had come across the term as this might go towards providing an understanding of how he had come to understand it in the way that he did. Once again he replied that he was unsure of when he first encountered the term but indicated that it may have been in discussion with colleagues at the workshop. The following explanation provides an insight on how Norman understands 'context':

> *In the past mathematics was taught with examples and formulae and the pupils did not know how any of this was relevant to their lives. With mathematical literacy the mathematics has to be taught with examples that come from real life that is contexts that are of relevance to the pupils.*

His explanation showed a relatively deep understanding of 'context' in mathematics, which raised the question as to why his actual classroom practice lacked this depth? Answering this question may require considering that Norman's instructional practice separates the teaching of content from the context in that once algorithms and formulae have been established they are only then extended into a context. The curriculum requirement is that both content and context are considered as a process and are not to be taught separately. The impact of Norman's pedagogical understanding of the use of context in mathematical literacy is evident in his instructional practice, in the limited use he makes of it. However, this is not the case in his assessment practice.

6.8.1.4 Exemplar Paper

The exemplar paper that Norman acquired from a colleague a week before the research study began seemed to give Norman the confirmation that he needed in terms of what he was teaching to be right. This perception of Norman's was confusing for an analyses of the exemplar paper revealed it to be aligned with the curriculum 'mathematics in context" intentions that were not visible in his instructional practice. The exemplar paper questions embraced themes, which were explicitly stated as headings and were of relevance to the learner's lives, engaged mathematics in context throughout, and allowed for reflection in analysing answers.

None of these distinctive traits of the curriculum were used by Norman in any of his lessons, and even his test that showed a somewhat deeper appreciation of the curriculum lacked this obligatory profundity .Had Norman's reaction to the exemplar paper included any sign of questioning his practice it may have resulted in drawing upon the findings differently as his questioning may disrupt Norman's instructional status quo which in turn may have lead to a different and deeper understanding. Lacking in this however, Norman's reaction seemed to further establish evidence that his assessment practice and his instructional one varied considerably in terms of what was taught and what was assessed.

What was taught is content, and what was assessed or would be assessed, as he indicated that he would be using the exemplar paper as the assessment task at the end of the year, was the process of understanding contexts that involve the use of mathematics. Norman believed that this application could be done by his students, despite the fact that they were not presented with similar situations in class. His belief was based on his perception that the ability to do the mathematics implied an ability to transfer this knowledge to contexts that required it.

Why Norman understood the curriculum in the way that he did can also be explained through the way that this curriculum was introduced to him and to his school.

6.8.2 Introducing Mathematical Literacy to ERHS

Mathematical Literacy was introduced at ERHS based on a decision that the school principal took in consultation with the head of the mathematics department. These discussions did not include Norman and as indicated earlier Norman was given the curriculum document and told he would be teaching the subject at the beginning of that same year. No further discussions took place at the time and Norman said that the departmental meetings never included dialogue on mathematical literacy other than planning to complete the Grade 10 curriculum by year-end. Norman's response was matter of fact and not a grievance, adding that discussion was not really essential, as he understood what he had to teach.

The reason for the absence of dialogue during the introduction of the curriculum between Norman and his departmental head is unclear. Was it simply based on Norman's understanding that he could teach the required content, or was it also an indication that his departmental head did not understand the curriculum any differently? If the later were to be conceded it would raise an important point. If the leadership at Norman's school is not in a position to guide him in implementing the new curriculum, who will?

6.9 Learner's Views

Initially, the design of the study did not include questioning the learners, however several of Norman's responses pertinent to the research questions expressed views on the learner engagement with the curriculum. Wanting to explore if these beliefs of Norman were founded in the actual learner experiences, as they seemingly played a part on how he proceeded to implement the mathematical literacy curriculum, I designed a questionnaire which with Norman's permission and been an option for the learners was distributed to his entire class. Of the thirty-eight learners thirty-six were present that day and thirty-three stayed and responded.

The reactions of the learners challenged several of Norman's judgments. Firstly they all expressed that they were finding mathematical literacy difficult, but opposing what Norman had said they did not point toward reading and context as the problem but rather the actual mathematics itself. They listed symmetry, proportion, graphs and percentages as sources of difficulty with only one learner writing 'the sums are too long'. Secondly, of the thirty-three respondents only three believed that they could use the work they were doing in the mathematical literacy class in real life, with the balance communicating that they could not see any real life bearing. Thirdly their encounter with the subject did not echo the enjoyment that Norman had spoken about, it spoke about anxiety and stress. I provide some of the responses that take in the governing themes that became apparent in order to lay bare the depth of negativity and stress that the seeming difficulty of the subject was triggering in Norman's learners.

6.9.1 Learner Transcriptions

> Some people say this is similar to real Maths because Mathematical Literacy is becoming harder and harder. I do not understand what we are doing; it causes so much stress for us.
>
> This year is very different[20]. I cannot understand. Can you please talk to government about this situation of maths, because it gives us stress?
>
> No difference, just much difficult.
>
> No different, in the first term this year I was doing Mathematics and failed so I changed to Mathematical Literacy thinking it would be easier. It is not, I am still failing and now I understand nothing.
>
> It's kind of the same as mathematics from last year, but only much harder. I hate coming to class because I know I won't understand anything.
>
> I think that there is no difference, it is very difficult and upsets me.
>
> *Very difficult and causes me a lot of stress.*
>
> *No difference, but then again maths is not one of my favorite subjects. I hate it.*
>
> It is suppose to be easier but it is not, it is so much harder.

[20] The use of 'different' is to previous mathematics instruction.

Its just like maths to me, I understood Mathematics better than literacy, I took literacy to make life a little easier, but it is harder.

Maths has its own people, not us; we cannot even do this easier subject.

It's supposed to be easier for the kids that can't do maths but actually it's just as hard and it's hard for me to do something I don't understand.

This is a bigger monster than mathematics; we are not robots or geniuses like our teacher.

Mathematical Literacy is for the people who cannot understand math, some people are not smart enough but now I feel even stupider because I still can't do it.

That it does not really help and it does not help me because I clearly can't do maths.

Having read the anonymous student responses Norman looked at me, smiled, and simply said," I told you so, the subject is way too difficult". Having earlier told one of his classes that this is the 'mathematics of oranges and bananas' his opinions and views seemed to be confused. Was the curriculum easy in comparison to Grade 10 Mathematics of the past, but still having a standard too difficult for the learner's in Norman's class that created this binary viewpoint? How will Norman address the level of difficulty his learners are experiencing? Will all this negativity affect the implementation pathway in Norman's class?

6.10 Synthesis

This chapter described Norman's understandings and perceptions with regards to the new mathematical literacy curriculum, depicted his observed instructional practice, and explored why the curriculum is implemented in the way that it is. When unpacked collectively, these findings point to discontinuities between Norman's understandings of the mathematical literacy curriculum and the actual intentions of the official curriculum.

The continuities that are evident are understood at a surface level; but there are also divergences between his claims and his instructional practice. Additionally, a positive correlation also seems to exist between his surface understanding of the curriculum and the implementation of the curriculum in his classroom.

The understanding Norman holds appears to be firmly rooted in his interpretation of the textbook he is using, the interpretation in turn a by-product of beliefs and pedagogy entrenched in his instructional practice. A further in depth analyses of the findings will be provided in Chapter Eight, which will also include the theoretical underpinnings for these findings.

The next chapter looks into Michael Michaels understanding and perception with regard to the mathematical literacy curriculum and the way in which he proceeds to implement this in his actual classroom practice.

CHAPTER 7

The case of Michael Michaels:
'I am too qualified to be teaching mathematical literacy'

> *There is a shortage of qualified mathematics teachers, and to use me to teach it is such a waste. The syllabus is easy and anybody who can read is just about qualified to teach it*[21]*.*

7.1 Introduction

This chapter presents the second teacher's (Michael Michaels) understanding and instructional practice with regards to the implementation of the new Mathematical Literacy curriculum. I begin the report by providing an explanation on how I came to know Michael and introduce him as both person and educator. This is followed by a description of the educational milieu in which he works followed by an account of the similarities and differences between his understanding of the curriculum document and the curriculum document itself.

Michael's perception of his instructional practice is then measured against his actual observed classroom practice, with the chapter concluding with the findings of why Michael teaches mathematical literacy in the way that he does. Emerging themes and findings from this case study, are framed within the three research questions and are further analyzed and compared with those from the previous case study and, ultimately, in the light of the conceptual framework in Chapter Eight.

7.2 Finding Michael Michaels

In April of 2006 I attended a Mathematical Literacy workshop with a colleague from my school in order to observe the training that teachers were undergoing due to the

[21] Quotation from Michael Michaels during an interview (July 2006).

introduction of mathematical literacy. It is at this workshop that I met Michael Michaels. Of the sixty educators present at the workshop, Michael was not only the most vocal but also received the most positive feedback on his responses from the instructor throughout all the group presentations that he did.

On the third day during lunch Michael approached me and asked me if I was Greek. Having responded in the affirmative and establishing that his origins were Cypriot we continued with a lengthy and pleasant discussion on how we had grown up not even ten kilometers apart and had never before met each other. The Greek community on the East Rand was a very close community while we were both growing up and often held many social functions at which everybody got to know each other, for whatever reason our paths had only just crossed. Having heard that we had not yet offered the subject at the school were I was employed he invited me to contact him if we did so in the future, and had any questions pertaining to this new curriculum.

At the time it did not cross my mind to consider him as one of the case studies, as I initially thought I had already secured my respondents, the details of which I discussed in Chapter Four. After failing to do the research in the schools I had initially targeted, I contacted Michael and explained my study to him. Not only was he happy to hear from me but seemed extremely enthusiastic with been asked to participate in the research study; all he needed to do was to discuss it with the principal and he would contact me as soon as the permission was granted. Michael phoned me two days later and told me that his principal had agreed to allow me to observe his teaching practice.

I made an appointment to discuss the study with the principal and during this meeting it became clear why Michael was so enthusiastic. The principal told me that Michael was flattered that I had chosen him out of all the educators who attended the workshop to conduct the case study with. In a way, this was true, and I left the topic with no further discussion. I conducted the first interview with Michael that very afternoon and the classroom observations began three days later.

7.3 Curriculum Vitae - Abridged

MICHAEL MICHAELS

DATE OF BIRTH

15 May 1965 (41 years old)

EXPERIENCE

1990 – Present FET High School
Educator:
Mathematics Grade 10 & 11
Mathematical Literacy Grade 10
Physical science Grade 10

EDUCATION

1983–1985 University of the Witwatersrand
Bachelor of Science:
Mathematics III
Chemistry III
Physics I

1986 University of the Witwatersrand
Higher Diploma in Education
Teaching Subjects: Mathematics & Science
Elective: High School Sports Coaching

MILITARY SERVICE

1987 – 1989 South African Defense Force

INTERESTS

School Productions

Music

Michael is a forty one year old male educator at FET High School, one of three English medium high schools in a city situated twelve kilometers east of O.R.Tambo International Airport, in Gauteng, South Africa. Of Cypriot heritage, he is a first generation South

African Cypriot with Greek and English as the dual medium home language. He attended the University of Witwatersrand were he completed a BSc degree majoring in Mathematics and Chemistry. His academic degree was followed up with a professional teaching diploma with mathematics and physical science as his two teaching subjects.

His first choice was to study engineering but this, at the time, was not an affordable option to him and his family. He proudly describes the sacrifices both his parents made working late hours in a corner cafe to raise him and his three sisters giving them as many scholarly opportunities as the wealthier parents of his friends did. When the guidance teacher at the school suggested that he go to university on a bursary, as this could be easily obtained, for the then education department was partial to white males who wanted to enter the teaching profession, particularly in Mathematics and Science, he decided to change his career choice as it would be a lesser financial burden to his parents.

What is more was that he parents considered this a stable and esteemed profession. He explained that in Greece and Cyprus high school teachers are called '*professori*' and not educators like their primary school counterparts, which seemed to further sanction the career that he had chosen. Michael recalled the application process, which entailed a full physical examination including a urine test, and an interview with three men in dark suits and his then school principal. Since then he has attended several interviews but none that have made him feel that he had as much to contribute to the South African society. Serving in the South African defense force did however register as a close second.

At the time of this research Michael was in his seventeenth year of teaching having gained nearly two decades of experience in the same high school. Seventeen years however does not account for the entire relationship Michael had had at FET High School, as this was also the high school he attended as a secondary school student. He describes these twenty-two years as some of the best times of his life, and the loyalty he feels towards the school is evident in nearly all that he says.

On arriving at FET high school he was initially given the senior science to teach, as the head of the science department was on maternity leave. On her return, the mathematics department was shuffled around and from that time taught mathematics as of grade ten to twelve. Despite not having received the promotion position that opened up two years ago in the mathematics department, for which he applied, he decided to stay at FET High School at least until a position in a private school became available.

Initially he was interested in a promotion post only, but this changed when he was not given the head of department position at the school at which he taught for over fifteen years. He believed that promotion in government schools was no longer possible for white males, as the appointments were not done on merit but on what he called "blatant affirmative action".

> *I am more qualified than my Head of Department, and have many more years of experience. In the beginning I was bitter about what happened but when you ask around it is happening in all the schools. Everyone who can is getting out, either leaving teaching or applying to private schools. I do not want to leave teaching, I love the classroom, but enough is enough. How much more can one go on giving without been recognized? The government, year in year out complains about the shortage of maths teachers, perhaps if they looked after them there would be some qualified ones left in their schools.*

Michael is also heavily involved in the schools productions and this dates back to his school days during which he annually participated in plays ranging from Shakespeare's Macbeth to musicals such as Grease. He has continued with this tradition of involvement, however this time being on the other side as choreographer of dance and even as director. This involvement he is passionate about, and readily admits that it would be one of the things he would miss most if he were to leave FET High School.

Uprooting his family and moving out of the city that he grew up in and has taught in for two decades also weighs heavily on the decision he has taken. However he does find strength in his wife's support for the decision to apply to private schools because being a teacher herself she relates to what they believe are discriminatory appointment practices in government schools.

In 2006 Michael's teaching responsibilities at FET High School included two Grade 10 and one Grade 11 Mathematics class, two Grade 10 Mathematical Literacy classes and one Grade 10 Physical Science class. Extra-murally he was involved in the schools cultural productions and the training and managing of the schools solitary chess team, a duty that he explained was handed to him, when the chess coach of many years left, as he was the only educator at the school who admitted to having known how to play chess.

The school timetable, Monday to Friday, is made up fifty-four thirty minute periods of which he teaches forty-two. Of the remaining twelve periods he is required to attend the one assembly on a Monday morning, and the rest he can use to mark, plan his lessons or socialize in the staff room as he admits he often does. Five staff members constitute the mathematics department which he is part of, of which two are white and the remaining three black.

Apart from Michael, the mathematics department is all female and younger than him. With the exception of the comments made on why his head of department was appointed, Michael spoke fondly of his department and described them as a "very close team".

> *We work well together and support each other as much as possible. We share our lesson preparation and help each other set tests. We have to stick together as a mathematics department, you know how it is, on parents evening we have the longest queues. Everyone thinks their child can do maths, but what they seem to forget is why they could not. I even like my head of department, it is not her fault she was appointed, for that I blame the principal.*

This glimpse of Norman's life history and teaching environment was informed by many casual conversations held over the five-week observation period and also by the questionnaire (Schedule A) whose one purpose was to gather such biographical information. Michael's background account is important as it is intractably linked to who he is as an educator, and as such is central to his thinking and understanding. Similarly, so is the context in which he finds himself teaching in.

7.4 Michael's teaching environment

FET High School is based fifteen kilometers east of O.R.Tambo International Airport in Gauteng South Africa. Founded in the early 1900's it was re-positioned after two decades from what were temporary grounds, to the land it now occupies and has occupied for over one hundred years. It is a popular school and attracts long waiting lists in every grade; particularly in Grade Eight were many of the learners from the feeder primary schools annually apply. The school is highly regarded by the surrounding community for both its academic and sporting achievements.

It is situated near the center of the city in which it is found, with one of the city's main roads running parallel with the north side of the school building. FET city is a bustling industrial area with several affluent residential suburbs surrounding it. The learners that attend the school are mostly from new middle class South African families. The school has a strong support of children from past parents that also attended the school. Historically it has produced several prominent figures of the city, including a town mayor and a local sporting celebrity.

It is a beautiful two story building that is both well developed and maintained. It boasts a swimming pool, expansive sporting grounds and an auditorium. Freshly cut lawns lead up to the office block, which is central to the design of the school and houses the principal, the two deputy principals and the administrative staff.

The principal and one of the deputies are black males with the second deputy being a white female, which is also the gender and race of the four administrative staff responsible for the daily running of the school which includes setting up appointments, typing, registering learners and collection of school fees. Academic facilities take account of two computer laboratories, two science laboratories a senior class and a junior class, one biology laboratory and a library on the second floor.

The computer laboratories each have twenty-five computers, which are all networked to the main server with continuous access to the Internet. The learners at FET High School have access to these laboratories during breaks and also after school, with a trained computer educator present at all times. The library is full of books, receives two copies of the daily newspaper and has several subscriptions to magazines such as *Pythagoras* and *Time*. It also has copies of the mid-year examinations and end of year examinations in each subject and for each grade. These are available to the learners at a nominal price charged for the photocopying which is mostly what the learners use the library for. The books and journals although available to the learners are hardly accessed and are used primarily by the academic staff as reference material.

One thousand one hundred and seven learners were registered at the school at the time of the research, with five classes in each Grade. Like most secondary schools in South Africa FET High School accepts learners from Grade Eight which, is the first year of secondary schooling, and provides for instructional development up to and including Grade Twelve, which is the exit point of high school in the country.

The racial composition of the school is an estimate, as the principal would not disclose this statistic. A bird's eye view during an assembly would place this at approximately forty percent white with the remaining sixty percent non-white. Once again this apparent statistic is only provided to establish the dynamics that have unfolded in Michael’s life, in particular with the appointment of the 'black' female head of department.

Mr.Sithebe[22], who has been the principal of FET High School for the past five years, readily admits that he makes staffing appointments that are conducive to transforming the racial composition of the staff room to be in profile with the learner body, but is assuring

[22] Alias used.

when he explains that at no time do any of his appointments compromise the educational standing of the school.

The staff body is fifty-four members strong and has five staff members that have been teaching there for over a decade. Roots run deep in the school and the pride and loyalty of both the staff and students is apparent, not only in the neatness of their dress, but also in their discourse that has as it main emphasis the schools achievements and proud academic record. Relationships in the comfortably carpeted staff room are seemingly sincere and the camaraderie with the principal speaks of a unique leader who is not only well liked by his staff but also very respected.

Having undergone an Umalusi[23] compliant Whole School Evaluation in the year previous to the research, the school principal is in possession of several statistics that make him and his staff proud. These include a comparatively competent staff body, a happy learner and parent community, and an operationally successfully functioning school. However the statistic that is most spoken about is the one that relates to bullying. The principal is quick to explain how the surveys conducted with the learner body during the whole school evaluation showed FET High School to have a statistic on learner bullying which was significantly lower than the average provided by the Umalusi records.

Contributing to this, the principal explains, is the no tolerance of any form of discrimination that is not only entrenched in the school policy, but in the beliefs of his staff. The students are continuously encouraged to have a high regard for this policy and are exposed to several discussions on respect and tolerance, not only in assembly periods but also during the morning registration period.

It took one expulsion after an arduous disciplinary hearing with a Grade Twelve learner who was found to be threatening and intimidating a new Grade Eight learner three years ago, to set the example of the sanction for any such behavior. It seems to have worked, and since then no hearings in this line of grievance have been held again.

[23] Council for Quality Assurance in General and Further Education and Training-in South Africa.

Classrooms at FET High School are relatively big, with approximately thirty-five desks and chairs in each with very little graffiti and as much litter on the floor. Freshly painted walls and windowpanes are further indicative of the Whole School Evaluation as are the posters on the wall pertinent to the learning area taught in the individual classrooms. Recent learner projects occupy most of the spaces on the boards in the classrooms, more evidence of, as Michael called it, “the big inspection”.

Michael acknowledges that his reaction was no different to that of the schools and joined them in window dressing his classroom with posters depicting mathematical formulae, various famous mathematicians, Einstein, and neatly typed up and enlarged copies of the learning outcomes for both the five learning outcomes in Grade Eight and Nine Mathematics and the four of Grade Ten FET Mathematics.Suprisingly, the Mathematical Literacy outcomes do not appear anywhere on his walls.

The classrooms also have radiators for heating built into the walls that were found to be continuously switched on through the bitter winter that accompanied this case study. Warmth however, also radiates from the students who are respectful and polite greeting visitors, staff and strangers in the corridors throughout the day.

High wire fencing surrounds the school and an electric gate is the main access to the school for visitors, learners, staff and parents. An intercom announcing ones arrival is situated near the gate, which has the metal crest of the school proudly emblazoned on either side of it. In the car park, is a flagpole, and the Student Representative council members, who rotate the duty amongst them, religiously bring it down at the end of each school day, and hoist the South African flag up every morning. Car park shading is provided for the senior management staff that also has reserved parking bays with the positions that they hold written on small but visible placards.

The foyer area outside of the school hall proclaims the schools history with photographs of highly achieving academic scholars and sporting teams whose results and records are written below. What does strike a visitor however is that these photos only run up to 1999 with the last seven years of the schools achievements not been reflected. Wooden boards with the names of the Head Boy and Head Girl[24] are mounted on the walls on the front of the school hall but once again only have names unto and including 1999, the year after which the prefect body was discontinued and the Student Representative Council introduced.

Academic time begins on a daily basis at quarter to eight and ends at three in the afternoon. Most weekday afternoons are filled with sporting activities which include many practices and as many matches. Student involvement in the extra-mural offerings is compulsory and the field is filled with enthusiastic sweaty learners not only on the weekday afternoons but also on many a Saturday morning.

The mathematics department, as previously mentioned, is five staff members strong and is regarded as one of the best by the surrounding schools, evidenced in casual discussions that I had at one of the cluster meetings Michael invited me to attend with him during the course of the research study. His head of department is a dynamic lady who is a staunch disciplinarian not only in the classroom but also in the way that she conducts the weekly mathematics department meeting. It is a 'youngish' department with Michael being the only member who is over forty years of age. Departmental dynamics on observation surface as honest and open, with several meetings resulting with a walk to the well stocked tuck shop for refueling after methodical planning.

7.5 A Snap Shot of Michael's Grade 10C Mathematical Literacy Class

Grade 10 C had thirty-two learners doing mathematical literacy, and Michael Michaels had been assigned to teach this class, which is one of the two grade ten mathematical literacy classes that he taught in 2006. Of the thirty-two learners twenty-seven failed the end of year examination in Grade Nine. Their parents were contacted by Michael's head

[24] Traditionally in South African schools, these members were the heads of the prefect body which was normally elected without transparent procedures.

of department at the end of that year and invited to a meeting to discuss their subject choices for Grade Ten.

At the meeting, the principal, the head of department and Michael spoke to the parents with regards to the difference in the level of difficulty between mathematics and mathematical literacy and also provided the parents with information on what mathematical literacy entailed. Collectively they recommended to the parents and learners that they should do mathematical literacy, as it was not only easier but of more relevance than the 'abstract' syllabus of Grade 10 Mathematics. Michael explained that the only concern of the parents at the time was whether taking the subject would prevent their children from studying at a university once they had completed high school. Having been assured that their children could study further at a university both the parents and the learners were satisfied with taking mathematical literacy as a subject and not mathematics. Part of Michael's explanation of this process included the following:

> *We sold it to them. It was not difficult to do, most of these pupils have never coped with mathematics and this was an option out of doing mathematics without closing the door to university. Most parents were relieved to hear that they could go to Grade Ten and did not want to repeat the year (Grade Nine). The work is really easy but some of these pupils are still not copying, they are passing, but only just.*

Three of the remaining five learners elected to do mathematical literacy of their own accord and their Grade Nine results showed that although they had passed the end of the year examination they had only managed to do this by several percent. The last two, were new students to FET High School and were placed in the mathematical literacy class because of a history of difficulty in mathematics in their previous schools.

Of the thirty two learners thirty one had attended an ex-Model C[25] primary school with English as the language of instruction which was however only the home language of twelve of the learners with the rest having several African languages. What was noticeable in this class was that twenty-eight of the learners were 'Black African'. This

[25] During apartheid years these were white only schools.

majority representation was also the case in Michael's second class of mathematical literacy. Statistically, at FET High School eighty nine percent of the grade ten learners doing mathematical literacy were 'Black African', which on the surface seemed at odds with the schools approximated racial constitution.

All the students had a mathematical literacy textbook, which was the same as the one Michael used to teach with, and had access to the new Casio fx ES scientific calculator, both of which belonged to the school. The students were allowed to take the textbooks home on a daily basis but not the calculators. Michael, when required by the nature of the lesson issued these to the learners, which they diligently returned at the end of each lesson. On rare occasion they were permitted to take them home on weekends if there was homework that required them and the more senior mathematics class of Michael's, namely Grade 11 B-Mathematics, was not using them. Michael explained that this was not a trust issue but that he had only forty such calculators, which he required for the teaching of all the classes that were allocated to him, and his priority had to be the more senior learners, which in turn, in the following year, would be the current Grade 10 C's.

Seven of the learners in Grade 10C did have a calculator that belonged to them and all of the learners possessed a hard covered note book which they used to take down notes and paste worksheets that were handed out. The notebooks were neatly kept and the learners used these exclusively for mathematical literacy.

This class was taught mathematical literacy in Michael's classroom, which was positioned at the end of a corridor on the second floor of the school. The classroom itself was well ventilated, neat, had desks that were arranged in groups and positioned in such a way that the learners could see the blackboard at the front of the classroom even though some learners needed to crane their necks to do this. Although the desks and chairs occupied most of the floor space, because of their positioning Michael could move amongst the learners with relative ease.

Having established Michael's working milieu, I precede with a discussion of the research findings that pertain to the studies research questions. I begin with framing the evidence in research question one.

7.6 Michael's understandings and perception of the purpose, problems and possibilities contained in the mathematical literacy curriculum.

Evidence for research question one, what do teachers understand to be the purposes, problems and possibilities contained in the mathematical literacy curriculum, was obtained from various data points as outlined in the research design and methodology chapter, namely Chapter Four. These points included semi-structured interviews that preceded the classroom observations (Schedule C), casual conversations and the semi structured interviews that were held after classroom observation (Schedule D), the questionnaire containing both open and closed ended questions (Schedule A), an in-depth document analysis of curriculum and related guidelines (Schedule G), and notes from the researchers journal (Schedule J). An explanatory theoretical analysis of the findings will follow this description and exploration in Chapter Eight.

7.6.1 Identity dilemma

Michael knew he would be teaching mathematical literacy at the end of November 2005, which was when he was asked to attend a meeting by his head of department during which together with the principal were to inform the parents that their children should do mathematical literacy in Grade Ten. He was not asked if he would be willing to teach this curriculum nor was it explained to him why he was asked to be the only member in his department to do so. Why he never asked for an explanation or the motivation that his head of department had used to assign the responsibility of this new curriculum to Michael was unclear.

What was clear however is that Michael did not believe that he should be the one in his mathematics department that should have been asked to teach it:

> *Younger teachers should teach the Mathematical Literacy or teachers who are not as qualified as I am. Teachers who have experience teaching standard grade would be the best suited, they know how to handle the weaker pupil. Initially it was reported that Geography teachers would teach it, I think that this is necessary. It is important to use the one's that cannot teach Higher Grade Mathematics. There is a shortage of good Higher Grade teachers, everyone knows that. To use me is a waste. The syllabus is easy and anybody who can read and add is just about qualified to teach it. She (head of department) gave me both classes to teach, she did not even consider given it to the other staff.*

Continuing he added:

> *It is politics all of this .There is not much I can say because then it will seem that I am racist because I think I am a better teacher than the rest of my department. Teaching Mathematics is what I love; this is not real maths. Do they think that I cannot teach mathematics? My results have always been excellent. I am not a mathematical literacy teacher!*
>
> *This is why I am looking to apply to a private school, and then I do not have to mind my p's and q's. I can just get on with teaching what I love, and be respected for what I teach. I have always loved mathematics, I got a distinction*[26] *in Matric, and now I am told to teach mathematical literacy...* (he shakes his head).

Michael's attitude towards having been told to teach mathematical literacy was not only negative but also emotional. His sense of disbelief that he was the one teaching mathematical literacy was tangible, as tangible as his insistence that he loved teaching Mathematics. What was however intangible was why he held this reality. Why did he understand that educators teaching mathematics as opposed to mathematical literacy were somehow the stronger teachers? Why did he believe with such strong conviction that he should not be teaching mathematical literacy or be known as the mathematical literacy teacher? Were these views intrinsic to his understanding of the value and status of mathematical literacy, or a result of the public opinion, which he understood, held mathematical literacy with low regard? How did this negativity and apparent threat to his

[26] A distinction is 80% and above in a subject and is a milestone in the end of year, external, Grade 12 examinations in South Africa.

teaching identity that he was feeling, impact on the implementation of mathematical literacy in his classroom?

Honesty and openness were character traits that Michael exhibited throughout the study as was the struggle he was experiencing on what it really meant that he was now no longer only a mathematics educator but also a mathematical literacy one as well. Despite his expressed feelings he did however articulate enthusiasm and motivation to teach the subject:

> *I am not saying that I will not do my best. I enjoy teaching mathematical literacy because pupils who never before passed mathematics now have an opportunity to pass and when they realize that they can pass they will start enjoying coming to my class. It's just that it is not a challenge. You do not put up a sum and think I hope they don't ask me for an answer now, because sometimes you cannot just see it. Then you go home and do it, and think uhh, this is tricky but only because it is different. It is exciting the next day, to see which pupil managed it. It's just; I do not want to be known as a mathematical literacy teacher only. This is something extra I do, not who I am.*

Michael identified himself as a mathematics teacher and wanted to continue to do so. His love for the subject and ability in it, had contributed towards this construction, which he was proud of. With the teaching of mathematical literacy, he was however confronted with what he perceived as a threat to this identity. He did not want to be known as the mathematical literacy teacher. In further interviews it was evidenced that he believed that to be known as a mathematical literacy teacher implied that he was not only a 'lesser' teacher than those teaching mathematics, but also less intelligent:

> *At least I still teach normal mathematics this year. But what will happen in the future if I stay here? Teach all the mathematical literacy? They (parents and students) will think it is because I am stupid, you know, not capable of teaching mathematics.*

For Michael it was evident that he believed that mathematics teachers were considered intelligent, or at least more intelligent than those teaching mathematical literacy. As such, the teaching of this new curriculum and the possibility that it may impact on how he was perceived by the parents and students, threatened the professional status of his identity as an educator. Was this further linked to how he understood the nature and purpose of the new curriculum?

7.6.2 Broad understanding of implementation

Michael indicated on the questionnaire that he understood the Mathematical Literacy curriculum to a <u>large extent</u> and that it provided guidelines for implementation that were however not flexible. The associated Learning Programme Guidelines and Assessment Guidelines he also declared that he understood to a <u>large extent</u> and further showed that he had copies of all three documents. Implementation guidelines, as for the curriculum document he found to be descriptive and allowed for no flexibility. He explained this as follows:

> *Implementation of this curriculum is easy, the content is simple stuff and relevant to teach, however it is rather prescriptive in that the curriculum is long and to finish it in one year is not to do justice to the weak pupils who are taking the subject. If it (curriculum) was shorter I could spend more time on the sections that the pupils find difficult, which given their maths ability with which they come into Grade Ten is nearly all the sections. I was doing compound interest with them a while ago, and instead of doing questions that they would find interesting I had to spend time showing them how to use a calculator. As soon as I changed the unknown in the formulae they were stuck and we had to go back to solving equations with various unknowns.*
>
> *This happens all the time, these pupils do not have the basic skills, these need to be taught before they can apply them. We spend so much time on the actual mathematics that introducing interesting contexts, that they have told us to do, would slow us down so much that we would not complete the syllabus at all. It is obviously better to teach less and teach it well, than to finish the syllabus and have no children understand the work. But we cannot do this because what happens if you leave out a section and they need this in the matric exam? If the pupils come out and complain that it was never taught the teacher is in trouble, if the work was taught and the pupil did not understand it that is a different story.*

Michael is clearly conflicted in the way that he is implementing the curriculum (too fast) with the way that he would like to. Speed seems to be winning, as he believes that, that is what the curriculum document requires of him. This perception does seem to be aligned with the curriculum document that not only spells out the learning outcomes that need to be 'taught' but also the content that each outcome requires. Taking the Data Handling outcome as an example, Michael emphasized his point by showing me the following part of the curriculum policy:

> The learner will investigate and interpret situations, which can be dealt with using statistical techniques. The following and other content and concepts will assist the learner to do so.
> Grade 10
>
> - Construction of questionnaires.
> - Populations.
> - Selection of a sample.
> - Tables recording data.
> - Tally and frequency tables.
> - Single and compound bar graphs.
> - Pie charts.
> - Histograms.
> - Line and broken-line graphs.
> - Mean, median, mode.
> - Range.
> - Relative frequency.
> - Probability. (DoE, 2003:41).

At a glance of the curriculum, Michael's concern seems justified. However a deeper inquiry into the curriculum document reveals that the progression of content over the next two years is diminished with an increase in complexity of situational contexts. The curriculum document further specifies that the,' content must serve the Learning Outcomes and not be an end itself' (DoE, 2003:38). Differentiation of content from context, which is misaligned, with the curriculum document, seems to be Michael's difficulty with time management.

A deeper understanding of the curriculum as a whole and also a deeper understanding of teaching 'mathematics in context' would perhaps allow Michael to hold a different view about the actual length of the curriculum. The question that this raises is how and when this will take place as Michael had already attended a Mathematical Literacy Workshop that he found to be of little relevance:

> *The workshop was a waste of time. They spend the entire time showing us how to teach and prepare a lesson. Perhaps for those teachers who cannot do mathematics this would be worthwhile. Perhaps they should have two different workshops, for those who can do mathematics and are qualified and those that have never taught mathematics before. Maybe it will help them. I know what a budget is. They spend so much time on the financial aspect of mathematical literacy. Anyone with a degree knows all that stuff. It then becomes a matter of adding a context and showing the pupils the application of what has been taught as it applies to real life examples.*

Having analyzed the workshop notes that Michael still had in his possession, I was acutely aware that the emphasis had been on the process of teaching 'mathematics in context' which reflected the curriculum intentions both in terms of purpose and possibilities, however no emphasis was placed on explicitly stating that the teaching of the content could not proceed the introduction of context, this was only clearly stipulated in the curriculum document. Was this why Michael was not attuned to this? Why did he process all this to imply that the only change required was adding on context after content had been taught? Granting the time obstacle, would this surface level understanding of the curriculum intention further impact the implementation pathway of Mathematical Literacy in his classroom? Would Michael even be aware if it did?

What seemed to also meaningfully impact on how Michael proceeded with the implementation of this new curriculum was an examination that was to take place two and a half years down the line, from the time of the study. The role that the externally set matric examination plays in the implementation pathway of this curriculum is pivotal as learner attainment is explicitly, as Michael stated, sacrificed for personal objectives, which mainly include avoiding school sanctions.

The reality of the pressure of the grade twelve externally set examinations is not unique to mathematical literacy as it has been part of the South African secondary school assessment landscape as far back as can be remembered. However acknowledging the reality of the damaging role these examinations play as opposed to 'best practice' play a part on how Mathematical Literacy is unfolding in Michael's classroom. What is pertinent is why Michael does not take in hand the circumstances he is faced with in a changed way? Why does Michael not question if there is a way to finish the curriculum and avoid the sanctions that he so fears while at the same time addressing his learner's needs?

Conceivably this would require a deep change, necessitating the abandonment of past practice and beliefs. A change that if it is to transpire will call for both external and internal forces that question and challenge both Michael's perceptions of the role of these externally set examinations and hence his instructional practice. What remains unanswered is, even if these forces exist, how and why will they reach Michael?

It is important to point out that that these findings only reflect Michael's awareness and understandings at this particular point in time. As this was only the first year of implementing mathematical literacy and less than eight months down the line since the introduction of this curriculum in the actual classroom, these beliefs and understandings could change over time. However what is germane is that if the change is not sought by the teacher the understanding may remain at the same level indiscriminant of elapsed time.

7.6.3 Concept Definition

Michael defined Mathematical Literacy as a concept as follows:

> *It is the equivalent to literacy in reading. Mathematics is a language and as such needs to be interpreted with a vocabulary of its own. You need to understand where you can use the maths you are taught in real life to understand mathematics. Mathematical Literacy is about teaching the pupils of how mathematics can be used in their daily lives. I think it is the beginning of mathematics.*

This response is indicative of a widely embracing concept classification that traverses over various definitions found in the extensive literature. What is purposely worthy of observation is his assessment that it is the 'beginning of mathematics' as it seemingly implies that one can only advance to mathematics when one is mathematically literate. This supposition that mathematical literacy is a preamble to mathematics then further positions the subject as 'lesser' than mathematics. A standard, which if held to be true can impinge on the unraveling of the mathematical literacy curriculum in the course of implementation in Michael's classroom.

7.6.4 Curriculum Purpose

Having asked Michael on what he thought the reasons behind introducing mathematical literacy were, he responded:

> *Because the government has done away with standard grade in all the subjects. In maths this is not possible, because they (students) cannot all do maths. So they have provided an alternative for these children that struggle with normal mathematics. It is the government's way of making sure that every child has some maths even though it is not real maths. If taught properly it can be useful because at least these children can make sense of simple maths that they encounter in their lives. If taught properly, everyone can do maths literacy; it is in reach of every child. The problem is schools commit treason when they take teachers who do not know maths to teach maths literacy.*

Michael's weakness to provide a response that takes in official curriculum purposes with respect to transforming the 'poor quality or lack of education' of the past which unopposed contributed to 'very low levels of numeracy' in the adult population of South Africa exposes Michael's thin understanding of the new curriculums purpose (DoE, 2003). The reference to mathematical literacy being 'not real maths' once again unveils his position with regards to the 'lesser' status that this curriculum holds.

Evidence in support of this also came from the questionnaire where he marked that he strongly agreed that mathematical literacy is a 'watered down version of the more abstract

Mathematics curriculum'. What is more, his reference to 'treason' is confusing for in a previous discussion he expressed a viewpoint that held that anybody with the ability to read could teach mathematical literacy. This contradictory data was perpetuated whenever Michael answered a question that was in his view a reflection of his ability to teach mathematics. When generalizing Michael's responses were found to be more positive about the nature and worthiness of the mathematical literacy curriculum, however when he framed the question more personally his responses were negative in terms of the value or worth of the curriculum.

In the questionnaire, Michael showed a somewhat deeper appreciation of the curriculums intended purpose. He indicated that he <u>agreed</u> that the curriculum be viewed in relation to the larger agenda of transformation and that it was a mandatory alternative to mathematics because of the 'low levels of numeracy' in the country. His inability to align his written response to his articulated reply is indicative of a lack of ownership of the curriculum. How these disparate mind-sets, between the personal and the general, the intended and the interpreted, invade Michael's instructional practice will be authenticated in the *Observed Instructional Practice* section of this chapter.

7.6.5 Curriculum Possibilities

Working on the postulation that the offering of the new mathematical literacy curriculum is an opening to expose learners not only to new and different knowledge but also to the acquirement of skills that are required for survival in the information age, I proceeded to ascertain what Michael believed these to be. Two lines of inquiry were used to explore this. One was a macro level inquiry on what mathematical literacy could offer on the whole and the second on a micro level, as to what opportunities each learning outcome could provide for.

7.6.5.1 Macro Level

The curriculum document interweaves the opportunities that it allows for with the actual purpose of the curriculum. This close link allows for the argument to be made that if a deep awareness of the curriculum possibilities is not held, a surface level of understanding purpose will also persist. Taken together, this level of understanding will play a significant role on how the curriculum unfolds in a classroom.

There are three distinctive contributions that the curriculum can provide for as outlined in the document. Firstly it provides for skills and knowledge that allow a learner to tackle everyday life mathematical demands and as such go towards developing 'self-managing' persons. Secondly it provides for developing numeracy that will enable a person 'to be a contributing worker' in the mathematically demanding workplace of current times, and thirdly empowers 'participating citizenship in a developing democracy' (DoE, 2003:10).

This third global opportunity is fundamental, for not only is it explicitly stated in the curriculum but is also part of the greater transformation of the fledgling democracy in South Africa as it goes as far as shaping policy:

> To be a participating citizen in a developing democracy, it is essential that the adolescent and adult have acquired a critical stance with regard to mathematical arguments presented in the media and other platforms. The concerned citizen needs to be aware that statistics can often be used to support opposing arguments, for example, for or against the use of an ecologically sensitive stretch of land for mining purposes. In the information age, the power of numbers and mathematical ways of thinking often shape policy. Unless citizens appreciate this, they will not be in a position to use their vote appropriately (DoE, 2003:10).

Michael indicated that he <u>strongly agreed</u> that the curriculum enabled learners to become numerically self-managing persons, contributing workers to society, and participating citizens in a developing democracy. He also <u>agreed</u> that it can achieve this, as it is suited 'to dealing with issues related to human rights, environmental and social justice', as it extends 'opportunities in engaging mathematics in diverse contexts', and also in that it 'values indigenous knowledge systems'. This initial indication of Michael's was in complete alignment with the intentions of the curriculum. However a doubt was cast on this level of understanding when he was asked to provide an articulated response, as can be seeing in his following statement:

> *Well, it is better than nothing. In most schools, not good schools like ours, a lot of pupils do not take mathematics not even on the standard grade. This is one way of making sure that every pupil does do basic mathematics. It is like reading and writing, everyone needs to be able to read and write-in the same way everyone must be able to do some mathematics. It has no other real positives, you know it closes most university doors; the good faculties do not accept pupils doing mathematical literacy. Like I said it is better than no maths at all. But that is about it. So that all pupils can do mathematics, even though it is an easier mathematics. The pupils doing mathematical literacy will at least leave school knowing how to do moths that they will encounter in their daily lives.*

One point in Michael's response exhibits that he believes that mathematical literacy can provide opportunities to the students that will allow them to deal with numerical situations that they are presented with in everyday life, which is indicative of some alliance with the curriculum document. However his articulated response by no means reflects the depth of understanding of the curriculum possibilities, as does his written one.

Given the claim that Michael has read and understood the curriculum to a <u>large extent</u>, the discrepancy between an ability to recognize the possibilities and an inability to express them when the visual is not present raises various contemplations. How is ownership of a curriculum arrived at? Why has Michael not yet acquired this? Will time play a role in reforming his perceptions and understanding? Is time pertinent in undergoing deep change when questions and reflection are absent at the onset of implementation?

These deliberations are significant as Michael exhibited a distinct detachment from the level of understanding he expressed in writing. He had an air of confidence and was always seemingly pleased with his responses, even though he guarded them with self-justification. The following vignette of one of his utterances exemplifies this:

> *I am lucky I can do this maths. I do not know how other teachers are copying though, there is a lot of new maths in the syllabus and they need to learn this before they teach it. At the workshop, some teachers did not even know the compound interest formulae. But nobody wants to talk about what is really going on because then it becomes a matter of race*
>
> He added:
>
> *I was at WITS and participated in many of the anti-apartheid demonstrations. We were tear gassed often and had to be very careful because we were warned if we were ever arrested by the police we would loose our bursaries, and yet we took our chances. Nobody is saying what we had was perfect but everybody is scared to comment on the new stuff because then it may seem you are racist and support apartheid education. Rather then settling down and teaching we are always introducing something new and attending courses, and we never really get into anything before it changes again. You know even this curriculum and all the other FET curricula are again going to be revised in a few years. Then maybe we will start over again. At the end of the day it is the pupils that are suffering. I feel sorry for the teachers who have to learn all this new stuff. I am fine, I can do mathematics How is the government helping them?*

His general perception that he somehow understood mathematical literacy better than other mathematics educators was seemingly based in his own self-confidence, as there was no proof of an external rationalization for this. This self confidence in his ability and understanding begs the question as to how will Norman acquire a deeper understanding of the curriculum when he does not in any way question his understanding thereof? Furthermore, how will his surface level ownership of the curriculum possibilities affect the implementation pathway of mathematical literacy in his classroom?

7.6.5.2 Micro Level

As previously discussed, in Chapter Six, the line of inquiry on the possibilities of the curriculum in terms of learning outcomes was pursued in order to extract the finer level of what opportunities and possibilities the curriculum could provide for. The design in pursuing the evidence for this question was kept very similar to that in the previous case study and once again scaffolding was used in the questions to compensate for the 'newness' of the curriculum's use of learning outcomes.

> Interviewer*: Learning Outcome 1 Number and Operations in Context. The learner is able to use knowledge of numbers and their relationships to investigate a range of different contexts, which include financial aspects of personal, business and national issues' (DoE, 2003:11). How do you understand this outcome with regards to learner opportunities?*
>
> Michael: *Money, money, money. This outcome helps pupils with all issues related to personal finance. It is one of the best sections, and when I was at school and did Additional Math*[27]*, this was my favourite section, and I really enjoyed it. It helps with understanding why people should try and not owe money to banks and how these financial institutions at the end of the day make millions from ignorant people. If you speak to teachers you will see many of them call mathematical literacy, financial maths, even some of the pupils do.*

Although the importance of the use of financial contexts in learning outcome one cannot be denied it is not exclusive to such contexts only. Michael's limited interpretation of one context only is representative of having attached a context to achieving an outcome which he is familiar with .The choice of context is not what is of as much connotation as is how he relates to it. His example of banking and interest seems to be a situation with which he associates and many of the learners may find themselves also having to deal with, if not presently, at some point in their working lives. What is lacking however is any mention of the use of a context that is sensitive to financial practices that are not of a 'Western Culture' that may be pertinent to the daily lives of a large majority of his learners and their families. The curriculum document states (DoE, 2003:43).

> *Another aspect of providing access and affirmation for learners of Mathematics is to look at examples in the variety of cultures and societal practices that exist in our country...The flexibility allowed by the*

[27] Additional Mathematics was an advanced program Mathematics offered to high achieving learners in Mathematics by secondary schools. In the FET, Additional Mathematics was not approved as a subject.

> *curriculum also promotes the incorporation of local practices as starting points for or applications of the Mathematics to be investigated.*

As contexts are central to the development of Mathematical Literacy in learners' it is important to consider the effect that the choice of these will have on the implementation of mathematical literacy. Will Michael's surface level understanding of the curriculum allow for contexts other than those that he relates to? Will he allow his learners to select contexts that they deem important and of interest? Will he respectfully convey them as valuable and essential to his learner's lives even though they may not be to his? What will oblige Michael to even consider alternative contexts?

Did Michael's response to the first learning outcome reflect an understanding that was common to the rest of the outcomes?

> Interviewer*:' Learning Outcome 2 Functional Relationships. The learner is able to recognize, interpret, describe and represent various functional relationships to solve problems in real and simulated contexts.' (DoE, 2003:12). What possibilities in terms of real life applications does this outcome afford the learners?*
>
> Michael: *This section is helpful because it teaches the pupils how to draw graphs. This is important, because they can use this skill to represent information in a way that is understandable to other people who do not .It also teaches them how to interpret graphs that can be found in newspapers and magazines. We have always taught this maths, you know the graphs we always do, straight line, parabola, circle etc. This new syllabus does not require that we teach all these graphs, only the straight line and interpreting other irregular graphs. I still teach them because I feel they are important, spend a bit of time on doing all the equations, circle, hyperbola, straight line and parabola and then show them how to sketch these. With the new calculator all they need to do is put in the equation and it provides them with the table of ordered pairs. Then all you do is plot them.*

Michael's explanation revolves around various functions that can be taught and interpreted when teaching towards acquirement of this outcome. He also finds it important to teach graphs work that he says is no longer in the syllabus. Learning Outcome Two is however not functions but Functional Relationships and includes a considerable array of various relationships that can be dealt with in various contexts of relevance to learner daily lives.

His interpretation of what is required in this outcome with regards to providing the learner with the learning opportunities that it can seems rather limited and entrenched in his past instructional practice. It is likely that it is not a lack of subject knowledge that is stirring his ability to comprehend the possibilities and intentions of the outcome as intended, but rather his lack of a deep understanding on what the nature of teaching for mathematical literacy advocates. Separating the content from the context in his explanation of his instructional practice is further substantiation of this frivolous understanding which will be pursued further in this chapter in the section dealing with his observed and claimed instructional practice.

In the questionnaire Michael indicated that he was not sure if the Mathematical Literacy curriculum was credible in quality and agreed that it provided for minimum conceptual knowledge. These indications were further manifested during the interviews where he often proclaimed that mathematical literacy provided for some skills and knowledge but only of worth as opposed to no mathematics at all. Beliefs and perceptions are basis for decisions and actions, and as such the value that Michael believes mathematical literacy holds will contribute towards the opportunities his learners are afforded in his instructional practice.

These values that Michael holds on the worth of mathematical literacy are not only negatively impacting on his status as a mathematical literacy teacher but also misaligned with those that the curriculum proclaims (DoE, 2003:11):

> The Learning Outcomes of Mathematical Literacy are designed to enable learners passing through the Further Education and Training band to handle with confidence the mathematics that affects their lives and so be appropriately educated for the modern world. They will be able to proceed with learnerships in career pathways that require Mathematical Literacy at the relevant National Qualifications Framework (NQF).

> Students proceeding to Higher Education institutions will have acquired a mathematical literacy that will enable them to deal effectively with mathematically related requirements in disciplines such as the social and life sciences.

This depth of opportunity and promise, as stipulated in the curriculum, does not form part of Michael's understanding of the purposes and possibilities contained in the curriculum. He seemingly compares the curriculum to the Mathematics curricula of the past and the core mathematics curriculum of the present, which he believes afforded and afford more skills and knowledge and as such judges this new curriculum to have lesser worth. Does his belief that he is sure he is teaching a subject of 'lesser' quality than Mathematics, matter to how he teaches it? Will his attitudes and perceptions shape the way his students act in response?

This thin and disconnected level of understanding the possibilities contained in the learning outcomes also surfaced in Michael's response on learning outcome three.

> Interviewer*:' Learning Outcome 3 Space, Shape and Measurement. The learner is able to measure using appropriate instruments, to estimate and calculate physical quantities, and to interpret, describe and represent properties of and relationships between 2-dimensional shapes and 3-dimensional objects in a variety of orientations and positions.' (DoE, 2003:12). How is this outcome of any significance to the learners' every day lives?*
>
> Norman: *We have only covered a small section of this outcome; we did the conversions, meters to centimeters, cubic meters to cubic millimeters things like that. We have also done area and volume, which was also part of the old syllabus. All this work is very important because it is useful in everyday life. The pupils can use this to work out measurements and volumes. We also have to do scale drawings, which I have been looking at because I will be teaching that section soon. This will really be worthwhile as interpreting and designing plans can help the pupils with house plans and budgets. Once they have a scale drawing they can use it to find out say the cost of building or painting a wall.*

Michael's ability to find and express real value in the pursuit and attainment of this outcome is in stark contrast to his overall perception of the value of the curriculum. This binary viewpoint is confusing not only in that it seems unpredictable as to which one will manifest in his instructional practice but also that he does not seem to be aware of his opposing held values. How is it that he holds the curriculum to be of little worth but can to some or other degree find value in all the learning outcomes? Why does this value that he does identify in each outcome vary in degree and also not form part of his overall evaluation of the curriculum? What are the implications of this on the pathway that Mathematical Literacy follows in his classroom?

The level of understanding that Michael had shown in his above responses was broken with that given for the fourth and last outcome.

> Interviewer*:' Learning Outcome 4 Data Handling. The learner is able to collect, summarize, display and analyze data and to apply knowledge of statistics and probability to communicate, justify, predict and critically interrogate findings and draw conclusions.' (DoE, 2003:12). What possibilities in terms of real life applications does this outcome afford the learners?*
>
> Norman: *Many possibilities. Data Handling is important because statistics and probability play a big role in our daily lives. The pupils benefit a lot because they are spending time on work that they not only understand and enjoy but work that is of benefit to their everyday lives. This section is a lot about representation and the pupils do not have to do many calculations. Once it is taught properly they understand it because it is not really based on mathematics from last year that they found difficult. Statistics is everywhere and an awareness of how this can be manipulated to put across a particular viewpoint, especially by politicians is very important in making sense of the reality around us.*

If one was to examine Michael's above response in isolation, as to how Data Handling can make available learning possibilities for learners pertinent to their everyday lives, one would be likely to conclude that Michael highly regarded the quality and opportunities that this new curriculum provided for. Added to this, if one was able to witness the fervor and excitement he expressed when answering this question one would be convinced that this conclusion was valid. However this response cannot be viewed in isolation of his overall perceptions, which contradict these individual retorts on the outcomes.

It is uncertain as to whether Michael felt obliged to answer these questions in the affirmative because of how that were posed or if he actually did value the quality of the curriculum but somehow felt that he should not express it. What seemed to be probable was that Michael was enjoying teaching the curriculum and found several of the sections valuable and enjoyable, but to admit this overtly may result in concluding that he was a mathematical literacy educator, a label that he clearly indicated that he did not want to wear. Why Michael had endorsed this label to be of little brand seemed to be more about an outside perception and less about how it actually suited him.

Further problems that Michael articulated are discussed below.

7.6.6 Problems

Implementation difficulties of new curricula are recorded in the literature extensively. In developing countries it is often the case that a shortage of resources, both material and in terms of human capacity, affect the implementation pathway of curricula as intended. However difficulties in implementation are not only as a consequence of resources and as such in this section I inquire deeper into the problems that Michael claimed to have in implementing the new mathematical literacy curriculum. Such insights may contribute towards gathering evidence on implementation difficulties in developing countries when educators are asked to introduce a new mandatory subject which in turn may inform the design not only of future revised versions of the curriculum but also of staff development programs.

In the questionnaire Michael indicated that the curriculum document <u>did not</u> provide guidelines for implementation. He also indicated that he was <u>not sure</u> if the two related documents, namely the Assessment Guidelines, and the Learning Programme Guidelines provided guidelines for implementation. Furthermore Michael reported that the implementation of the curriculum was <u>not</u> flexible.

7.6.6.1 Curriculum Flexibility

Having designated that he found the implementation of the curriculum not to be flexible I asked Michael what he meant by this. His response is given below:

> *The curriculum is very prescriptive of what needs to be taught. It is a lot of work and you cannot leave any of it out, as you need the grade ten work for grade eleven and the grade eleven work for grade twelve. At the end of grade twelve when they write the end of year matric exam I have to make sure that they have covered all the work. So it becomes difficult because I know that some of the pupils in my class are lost but if I slow down for them and re-teach a section or do revision I will fall behind in grade ten, then I will never catch up again. Can you imagine if any pupil fails mathematical literacy in matric? I know what they are saying, that no pupil will fail for at least two years, but we do not have this in writing so I do not want to take the chance.*

He continued:

> *But I have found a way around it. As far as possible I make sure that I teach all the mathematics first, in this way giving the pupils the maths they need to solve problems. Then depending on how much time we have according to my planning schedule I do examples, as many as I have time for. These examples show the pupils where the maths that they have done can be applied to the real world. I think that this is the best approach, because at the end of the day it does not matter how many examples you do with them anyway because the questions in the final matric exams will be different anyway. It is more important that they can first do the actual mathematics, the application will then come. It is like building a house, if you do not have the foundation no matter what picture you have in your head you will not be able to build the house.*

Michael's response raises two important matters. Firstly as mentioned earlier, the impact that the externally set end of year grade twelve examination has on his instructional practice, and secondly the choice of compromise that he has made, namely the teaching of content and then if, and only if, time permits the content in context.

7.6.6.2 Grade Twelve Examinations-End of Year

The pressure that Michael is feeling for an examination his learners are going to be writing in two and a half years time is explicitly impacting on the choices he is making as to how to implement the curriculum. This single assessment's influence is not only negatively contributing to the curriculums intentions but also to the anxiety levels of Michael's being. In casual conversations with Michael he revealed that the school places so much emphasis on its matriculation results that educators are either 'made' or 'broken' by this single exit point.

This is not a unique situation that Michael finds himself in as the role of the end of year externally set matriculation examinations features prominently in South Africa on judging secondary schools on an annual basis. Media coverage is extensive as is rhetoric on how schools will be held accountable for results that are deemed unacceptable. Statistics for this examination are rife and are used to shape policy both in terms of resources and curriculum design. Schools with disadvantaged learners in terms of financial status that achieve significant pass rates are touted as national examples further adding pressure on educators to achieve despite the difficulties they may be encountering.

7.6.6.3 Content before Context

Michael's solution to resolving the problem of a curriculum that is 'too long' is to place emphasis on the content and then to use context only and to the degree that instructional time permits. This practice is distinctly in dispute with the curriculum statement that claims (Doe, 2003:42):

> The approach that needs to be adopted in developing Mathematical Literacy is to engage with contexts rather than applying Mathematics already learned to the context. Research done internationally and in South Africa confirms this approach for young people as well as for adults.

Mathematical Literacy requires the teaching of 'mathematics in context', and as such Michael's compromise raises the following questions: If Michael had a deeper understanding of the pedagogy required to teach mathematical literacy would he be able to find an alternate compromise, to the problem of time, that would not go against the curriculum intentions? Why does Michael not have this deeper understanding? How does this 'compromise' affect the implementation of mathematical literacy in his classroom? Does Michael make any further compromises?

7.6.6.4 Learner Ability

> Michael: *The length of the curriculum would not be a problem if the pupils taking the subject had some ability in mathematics, even an average ability. But you must remember most of these pupils never passed mathematics in grade nine, some have never passed mathematics as far back as primary school. Now we are expected to teach them grade ten work and pretend that their past does not matter. Of course it matters. I have pupils in my class who do not know how to use a calculator; some do not even understand what a negative number is. If you do not start with the basics what are you going to build on?*
>
> Continuing he added:
>
> *To make matters worse, these pupils do not believe that they have the ability to pass maths. As soon as they see an equation they switch off immediately. It also does not help, that they feel stupider than the pupils doing mathematics.*

Students doing mathematical literacy at FET High School have academic records that indicate a poor history of mathematics achievement. Michael's struggle to complete the curriculum is, as he has expressed, not only because of the actual curriculum design but also as a result of the cohort of learners taking the subject. His articulated opinion is that the design in terms of length is appropriate for students that have a past indicative of at least an average ability in mathematics, which is not the ability of the learners that he finds he has to teach.

Building a foundation on which to structure mathematical literacy is imperative; however the question remains as to whether this foundation cannot be positioned in a way that is aligned to the curriculum document? The positioning of which may require relinquishing past beliefs and pedagogy that are entrenched in Michael's instructional practice and a redefining of his beliefs and understanding on the 'nature of teaching mathematical literacy' .The deep changes required are not necessarily the solutions to the problems but unless they take place the curriculum success can not be ascertained unless it is implemented as intended.

With so much emphasis on the unacceptably low levels of mathematical literacy in South Africa this opportunity to implement a curriculum that attempts to address these levels should feature prominently and continuously in staff development programs. Michael has attended the workshop and read the curriculum document, and yet his command of the curriculum intentions is thin. He is unaware of having to attend further training and as such, at least for the time being, it can only but be assumed that unless an 'external force' intervenes, his understanding of the curriculum will become established at the level of his initial interpretation.

Having raised the issue of 'mathematics phobia', I proceeded to show Michael a short extract from the curriculum that acknowledged his retort. This extract is given below as is Michael's response to what I showed him:

> Many local and international studies have shown the existence of a set of attitudes-described as 'math phobia'-in school-going learners and in the population at large. It is the responsibility of the teacher, in implementing this curriculum, to endeavor to win learners to Mathematics. Real-life contexts, which lend themselves to mathematical ways of thought, are ideal for doing this (DoE, 2003:43).

> Michael: *Always the responsibility of the teacher. What about the government's responsibility to the teachers? They come up with all these ideas and then leave us with the problem of making them succeed, without them asking us how they can help. Why don't they come into the classrooms and try to teach these pupils that have never passed mathematics? Let them try and finish the syllabus when the children*

> *cannot even use a calculator, and then they would see the real difficulties we are faced with. I love the example they provide, yes I can see that using contexts will now out of the blue, after so many years make them love maths? It makes me sick, let's blame everything on the teachers, so that the politicians can sit back and say that they have done their job. Are they blind to how many qualified teachers have left the profession because of all the changes they have made?*

Michael's outburst was surprising and contrary to his calm disposition that I had become accustomed to. It spoke of anger and an overwhelming sense of frustration at having to deal with repeated change and government sanctions. It is undeniable that the numerous changes in both curriculum documents and pedagogy have resulted in high levels of stress and frustration for many educators in South Africa. Statistics are commonly cited in the media as to the high number of educators leaving the profession and the low numbers of secondary school graduates entering the profession. This unbalance is even more momentous in subjects such as Mathematics and Physical Science. The difficulty Michael is encountering in educating learners that have a history of low levels of Mathematics achievement is to be expected as the subject was introduced as an alternative to Mathematics.

The expectation has been that the learners taking Mathematical Literacy, at least in the initial years, would be those that were not copying in the past with Mathematics. As such, it is confounding why the curriculum document does not provide guidelines, with any significant depth, on how the curriculum is to be implemented with students that have a history of learning difficulties, which can lead to 'mathsphobia'.

What is further as perplexing is why Michael does not refer to the documents that he was given at the mathematical literacy workshop. In one of these booklets in his possession, it can be seen that sessions were held during the workshop that dealt with the difficulties and problems that Michael had raised with regards to teaching students with mathematics difficulties. There was also a session and notes in overcoming and handling mathematics anxiety.

Despite all this, Michael had only taken away from this workshop an understanding and belief that he had the ability to teach the mathematics that was required of him in the mathematical literacy curriculum. It can then only be assumed that what Michael understood in this workshop is not what was been transmitted but what he, the receiver, required at that point in time. This for Michael was the need to believe that he had a command of the content of the new curriculum.

The implications of such deductions point towards designing staff development programs that stagger information transmission rather than overwhelming educators with new concepts and pedagogy at once off workshops. These deductions and the implications thereof will be analyzed and discussed in greater detail in Chapter Eight. I now proceed with the findings that pertained to the second research question.

7.7 How does Michael proceed to implement the mathematical literacy curriculum in his classroom?

Having provided a comprehensive discussion on how Michael understands the purpose, possibilities and problems of the new Mathematical Literacy curriculum I will now provide a similarly comprehensive discussion on how Michael proceeds to implement this curriculum.

The evidence for this was obtained from the following research instruments; Questionnaires (Schedules A&B), Classroom observation protocol (Schedule E), Document analysis schedule (Schedule F), casual conversations, and notes from the Researchers journal (Schedule J). The findings are portrayed within the frame of the second research question of this study, namely, how do teachers proceed to implement the mathematical literacy curriculum in their classrooms?

I will begin this section by providing Michael's claims with regards to his instructional practice while at the same time providing comparative analyses of his claims and understanding of the curriculum, as well as his claims and the intentions of the curriculum. The section will then be concluded with a description of his observed classroom practice with discussion of the similarities and dissimilarities of his claims, understanding and the curriculum document.

7.7.1 Claimed Instructional Practice

Differentiating between what Michael claimed his instructional practice to be and understanding what his perception of what it should be is an important one as it provides a deeper perspicacity on his actual understanding of the curriculum. This is because Michael's practice may not reflect his understanding but rather the circumstances of the reality in which he teaches. As this study is about how educators understand a new curriculum this differentiation is necessitated.

Michael indicated that he strongly agreed, that the teaching of mathematical literacy was an opportunity for educators to 're-define their thinking about the nature and teaching of mathematics', that it should be 'taught with life-related applications' and that it was 'similar to the previous Standard Grade Mathematics curriculum in teaching'. He agreed that teaching should 'favor process of context and content over content' and that the nature of mathematical literacy is such that 'it improves your teaching'. These findings reveal one major discrepancy.

If Michael believes that the teaching of this curriculum requires a re-thinking of his instructional practice why does he also hold that it is similar to the teaching of the 'old' Standard Grade mathematics, which clearly favoured content over process? This incongruity may be as a result of his thin level of understanding of what teaching 'mathematics in context' necessitates, with particular reference to his admitted instructional style of teaching content before context. Additional evidence for this that further explicates his understanding is provided in the following explanation of Michael's:

> *The teaching of mathematical literacy is similar to teaching standard grade mathematics as you are similarly dealing with weaker pupils and less difficult mathematical concepts. The only difference is that in mathematical literacy you expose the pupils to real life applications, whereas in standard grade mathematics word problems were not even part of the syllabus.*

His reference to word problems attaches some degree of synonymy between teaching mathematics in context and the aforesaid. This further illustrates how Michael understood the teaching of mathematics in context that is as similar to using word problems in mathematics. As this was only taught to Higher Grade pupils it may also further point towards why Michael avoids doing so. For the implication here would be, that if he believes that his students are mathematically weak, he will avoid teaching them 'mathematics' that was in the past restricted to the stronger higher grade pupils, as this may be at odds with the mathematical expectations he has of his students, which the literature claims should be high for effective mathematical literacy instruction.

The literature asserts that effective mathematical literacy teachers possess certain traits and behaviors, and these were put forward in the questionnaire. Michael specified that he strongly agreed that these should include 'promoting and valuing learner effort', and that educators of this learning area should be 'confident in their own knowledge and skills'. He further agreed, that effective educators should have 'high but realistic expectations of all learners', that 'both teaching and learning should be enjoyable', and that the mathematical focus should not be lost in the context but made clear to the learners. His response of what traits are required of effective mathematical literacy educators' shows an understanding aligned with literature in this domain.

Michael also claimed that his instructional practice at the time of the research mirrored the following statements:

- sensitive to indigenous knowledge systems,
- engaged real-world problems,
- integrated lessons with other disciplines,
- engaged learners both critically and creatively,

- made use of technology,
- allowed for reflection,
- feedback and assessment was integrated with teaching,
- process and context favored content,
- educator is confident,
- educator is motivated.

What was out of the ordinary was not that he had responded in a way that showed a deep understanding of the intended curriculum, but that of the twenty four questions he had only provided a response to the ten listed above. I questioned Michael on why he had not included a response for the rest. Taking the questionnaire back from me and looking at what he had marked Michael replied:

> *If you take for example point nine,' high levels of numerical skill are afforded' to say that there is room for improvement would imply that I am looking to change this, but the truth is I will not. As I have said there is no time. I suppose that I could have ticked it does not mirror the statement but the point I am trying to make is that I know that my teaching should mirror all these statements but I simply just do not have the time. Not with such weak pupils, my focus is to build the basics.*

His response echoed with his understanding of mathematical literacy as mathematics content. The high level skills that are required by the curriculum, for Michael implied more mathematics. As such he focused his teaching on building basic mathematics concepts for he felt he did not have time to extend the pupils beyond the basics.

Combining the findings, up to this point, show Michael's claims about his instructional practice to be similar to his understanding of the intentions of the curriculum document. Mainly, that Michael holds a surface level understanding of the required pedagogy and purpose as intended by the curriculum document. What is also evident is that Michael does not question his understanding but rather supports the problems he is faced with, with justifications on learner ability.

Inconsistencies scattered throughout his responses are also further explained away by Michael, as knowing what to do but not been able to do so, again listing the justifications already mentioned. It is pertinent to note that the 'problems' that Michael claimed he was experiencing in implementing the curriculum were all about the students and at no time did he express any of these to be associated with his actual understanding of the curriculum. Once again this point is critical, for if we are to assume that Michael's understanding of the curriculum requires greater depth then we must assume that this can only take place if Michael becomes aware of his thin understanding. The question that than arises is how and why will Michael become aware of this, having already both read the curriculum document and attended the Mathematical Literacy workshop?

The evidence acquired from the interviews and questionnaires showed that Michael's perceptions and understanding of the Mathematical Literacy curriculum varied considerably. There were continuities, discontinuities, confusion and contradiction. Where his understanding was aligned with the document, this seemingly was only on a surface level. The classroom observations will provide the necessary evidence that will either refute these findings or further validate them. What is more, it will provide for a more holistic interpretation on how mathematical literacy is actually being implemented in Michael's classroom, given his current understanding of the curriculum.

7.7.2 Observed Instructional Practice

Grade 10C, which is one of the classes that Michael teaches mathematical literacy to, was observed over a period of five weeks, which constituted forty-two thirty-minute periods. The follow up week, which formed part of the initial design, was not conducted as Michael fell ill and was absent from FET High School for eleven days. We were unable to reschedule this for when Michael did return to school, the students were writing end of year examinations.

The lessons are described and depicted below, mostly in their entirety. This is not only done so to emphasise the lesson content but also the discourse that was taking place in Michael's classroom. This format, I believe lends itself to the exploratory design of this study as it captures the essence of the instructional delivery of a brand new curriculum in Michael's classroom.

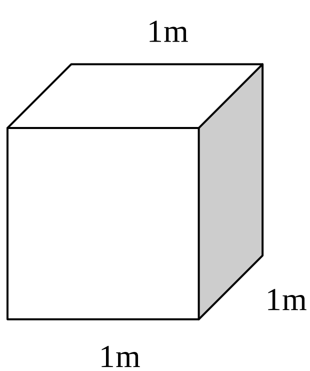
7.7.2.1 Observed Lesson: One

Thirty-two learners arrived to Michael's classroom punctiliously. They were neatly dressed in gray flannels, school tie, black school shoes and white shirts. Many wore the school jersey with a handful in the school blazer which had the school crest and motto sewn on the left breast pocket. The learners stood until Michael greeted them and then asked them to sit down. Michael proceeded to introduce me and spend a few minutes explaining to the learners why I was there. It was interesting to listen to what Michael had to say, stressing several times that I was not there to assess him or the students but only to observe. Once the explanation was over Michael began his lesson by writing on the board, which he interspersed with several explanations:

Surface Area and Volume

$1l=1000cm^3$ $1ml=1cm^3$ $1000l=m^3$

Mr. Michaels: *With units of volume it is important to be able to do conversions. What this basically means is, well let me show you. If you recall volume is equal to length times breadth times height.*



Mr. Michaels: *Use this relationship and find the following units. You have done proportion earlier on. If you find it difficult discuss with the person next to you.*

Convert the units of the area below to the units in brackets.

a) $1m^3 = \ldots cm^3$

b) $1km^3 = \ldots m^3$

c) $1mm^3 = \ldots cm^3$

The learners, without any sound, took out there books and began to copy down the work. After a couple of minutes Michael started to walk around the classroom answering various questions that the learners had. Many struggled and it was evident that the majority had no idea how to begin the very first question. Michael returned to the board, asked the learners to pay attention, and began to write, reading what he was writing.

1m=100cm

1km=1000m

1cm=10mm

Mr. Michaels: Remember this guys, we did it last week. You need to learn these relationships otherwise you will not be able to do the conversions.

Michael spent the remainder of the lesson answering questions that the students had. Near the end of the lesson he asked them to take out their textbooks and referred them to an exercise for homework. He asked if any of them required a calculator, which he then handed to all the learners that indicated in the affirmative. This was the end of the lesson and the end of a Friday afternoon school day. Once the learners had left I sat down with Michael to conduct the first post-lesson interview, in order to ascertain on why he had conducted this lesson and how he felt the lesson had been received by his students.

Interviewer: *What was the purpose of this lesson?*

Michael: *We are busy with area and volume, and today I wanted them to use the linear conversions that they had done in determining volume. I drew a cube because for those who struggle, if they remember to place the converted units on the sides of the cube all they need to do is multiply them out. This visual I find helps a lot.*

Interviewer: *In your view was this a successful lesson?*

Michael: *Yes, definitely. I gave them all the basics that they require. If they learn these they can apply the maths to any example.*

Interviewer: *Do you believe that the pupils acquired the skills and knowledge you expected of them before the lesson?*

Michael: *The one's that go home and learn the work, definitely. But it is important to learn the relationships off by heart. How can they do conversions if they do not know that one-centimeter is equal to ten millimeters?*

Interviewer: *In future would you do anything differently?*

Michael: *No, why, do you think I should?*

Observed lesson one was entirely focused on content. Having admitted that he always taught content before context this was to be expected. However, what was not expected was the homework that Michael had chosen for the learners, which was as devoid of context as was the lesson. The questions in the textbook that embedded conversions or allowed for their application were ignored in favor of the more straightforward and abstract mathematics conversions. Michael however was satisfied with how he had taught the lesson and believed that the students would acquire the necessary skills and knowledge if they learnt the 'linear' conversions by rote.

The next five lessons observed continued to deal with this learning outcome in an identical manner. Equations and formulas were continuously given and other than sterile diagrams of right prisms there was no engagement with any context let alone context of relevance to the learners. The two assessment standards that relate to this outcome of

Space, Shape and Measurement were completely covered in terms of mathematical content. The Theorem of Pythagoras was taught, areas were calculated, conversions were explained, and formulae for volumes of prisms were given. Michael had claimed that once he had taught the content he would, if time allowed, use what was taught and apply it to various contexts. In this section of work, Michaels' claim did not materialize. What did was his focus on the actual mathematics which he prioritized over all other requirements of the curriculum.

Within the first three lessons Michael's blueprint of instructional practice became clearly visible. Lessons would either begin with the marking of homework or an exercise continued from the previous day. The mathematics content for the particular day's lesson would then be placed on the board, explained and the instruction given to copy it down. The textbook would then be referred to and class work exercises and homework would be set. Perhaps this would change if he were to introduce a new learning outcome?

7.7.2.2 Observed Lesson: Seven

Having completed the section that he had been busy on over the past six lessons I looked forward to observing a lesson that required the introduction of Learning Outcome Four: Data Handling, to which Michael had responded with enthusiasm and a relatively deep understanding during the interviews. His lesson unfolded as follows:

> Mr. Michaels: *Today we will be starting with a section which you need to write a main heading, called Data Handling. Please copy down the following transparency*:

Data Handling

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Case	200	75	500	1500	775	1125	1000	800	1250	1200	600

a) In which year was the number of flu cases the highest?

b) In which year was the number of flu cases the least?

c) Between which years was this increase the highest?

d) Between which years was there a decrease in flu cases?

e) How many cases of flu were recorded for 1990 to 2000?

f) The population for the district was 1800, 10000 and 7000 in 1993, 1998 and 2000 respectively. What % of the population had the flu in these years?

Mr. Michaels: *I would like you now to divide yourselves up in groups of three and answer the questions.*

Within minutes the students arranged themselves in groups and proceeded with the task that had been assigned to them. Michael involved himself no further in the lesson and sat at his desk marking the Grade Eleven cycle test that one of his classes had written earlier on in the day. The post-lesson interview revealed that Michael was very pleased with his teaching of mathematical literacy to Grade 10C for the day:

Interviewer: *What was the purpose of this lesson?*

Michael: *To show the pupils how to interpret data that is represented in tables. We began with basics, like which is the highest and which is the lowest, what is the difference, calculations like this. When they work all these out then they can see the meaning in the information. Without the comparisons this is all lost.*

Interviewer: *In your view was this a successful lesson?*

Michael: *I thought I would start with something really basic. In this way the pupils could enjoy the work and realize that this section is really easy. They did not come to my desk with questions, so I am sure when we mark this work they will have got most of it right.*

Interviewer: *Do you believe that the pupils acquired the skills and knowledge you expected of them before the lesson?*

Michael: *Yes, they had to analyze data in the table that helps them to interpret data in any other tables. With statistics on AIDS always in the*

> *headlines, they can use these skills to understand this growing epidemic in our country.*
>
> Interviewer: *In future would you do anything differently?*
>
> Michael*: I would like to look for other examples in newspapers or magazines that show AIDS statistics. I think that this is important.*

Learning Outcome 4, as previously described, stipulates that 'the learner is able to collect, summarize, display and analyze data and to apply knowledge of statistics and probability to communicate, justify, predict and critically interrogate findings and draw conclusions' (DoE, 2003:34). Of these competencies only an analyses in terms of knowledge given was observed to apply to Michael's first lesson. The next two weeks of observed lessons showed no further engagement with any of the other skills, values or use of contexts that as indicated above he continued to say he needed to include in his lessons.

In the post lesson interviews it was also often made mention of the importance of comparison and yet discussions pertaining to comparative data were absent from the lessons. What is more is that it was found that Michael clearly regarded his lessons as successful and akin to the curriculum provisions. The observations made of his practice were not only far removed from the curriculum intentions but were also divergent from his claimed instructional practice. It became apparent that not only his thin level of understanding of teaching 'mathematics in context' impacted on his lesson instruction, but also his revered superiority of 'naked' mathematics. For Michael, a successful lesson entailed teaching the mathematical knowledge that the actual calculations entailed, believing that the students could then apply these to any other contexts that might arise.

His 'blue-print' of instruction was broken in observed lesson eleven.

7.7.2.3 Observed Lesson: Eleven

Michael began this lesson slightly different to the procedure of all previous lessons as he did not write the days exercises on the chalkboard but handed out a worksheet. He was still teaching Data Handling and had prepared a worksheet with three questions. This was handed out to them and they were told that it was to be returned to him at the end of the lesson in order for the work to be assessed. The learners were allowed to work in pairs but had to hand in individual work. The worksheet has been reproduced below in order to preface the discussion that follows with respect to the observations made of Michael's understanding of the curriculum requirements.

FET High School Grade 10 Mathematical Literacy
Instructions: Answer All Questions

Question 1

Fanelwa receives the following results on homework assignments: 85,71,87,72 and 79.Nomphelo received 65,99,86,90 and 51 for the same assignments.

a) Find the mean and range of Fanelwa's homework assignment results. (4)

b) Find the mean and range of Nomphelo's homework assignment results. (4)

Question 2

The following table gives the values of Jana's body temperature taken at different times during a day:

Time	04:00	08:00	12:00	16:00	20:00	24:00
Temperature (degrees C)	36,2	36,4	36,9	36,9	36,8	36,5

a) Find Jana's mean temperature for the day. (2)

b) What is the range of body temperature throughout the day? (2)

Question 3

At eight soccer matches the number of spectators present was:

873 681 752 942 621 826 1 036 1 092

a) Determine the median number of spectators at the matches. (2)

b) What is the range in the number of spectators at these matches? (2)

The lesson ended with the students handing in their worksheets. At the end of the school day, as had become common practice I asked him about the day's lesson:

> Interviewer: *What was the purpose of this lesson?*
> Michael: *To use the mathematics taught in contexts that are of relevance to the learners. The World Cup Soccer in 2010 allows for many such opportunities and the pupils are all soccer mad.*
>
> Interviewer: *In your view was this a successful lesson?*
>
> Michael*: Yes, I think so. You saw, they loved it. They spoke about the soccer non-stop. Also the body temperature, now they can go and discuss this in Biology.*
>
> Interviewer: *Do you believe that the pupils acquired the skills and knowledge you expected of them before the lesson?*
>
> Michael: *Mean, range and median have all been taught. Today the pupils were shown how these could be used in examples that are relevant to their daily lives. They are no longer abstract concepts.*
>
> Interviewer: *In future would you do anything differently?*
>
> Michael*: Seeing how much they liked the soccer question, I will find more examples dealing with soccer.*

The truth was that the learners had enjoyed the lesson. After several minutes into the worksheet it took one learner asking Mr. Michaels who he would be supporting in the 2010 World Cup Soccer for the entire classroom to view this as an invitation to start what became a very lively discussion. Michael's claim that the instructional practice should be enjoyable clearly mattered as it surfaced not only in the pleasure it seemed to give him in engaging the learners in the lively soccer debate but also with the enthusiasm he showed in his responses during the post lesson interview.

What is more pertinent to this study however is that the lesson had not met the curriculum demands outside the scope of actual mathematical calculations. The assessment standard curriculum requirements are: 'Calculate and use appropriate measures of central tendency and spread to make comparisons and draw conclusions, inclusive of the: mean, median, mode, range' (DoE, 2003:34). Of this requirement Michael's worksheet had only covered the 'calculation' assessment standard. There was no discussion about the 'central spread' or comparison of any of the data, which clearly lend them to such discourse, particularly in question one.

His superficial understanding of the teaching of mathematics in context was further more evident than ever, in his use of a picture of a soccer player, which was representative of the context. This 'dressing-up' of the content with pictorial representations of context was also evident in some of his assessment tasks that I looked at. These are discussed in a later section below.

Michael had also claimed that his instructional practice integrated other learning areas. What can be deduced from this lesson is that Michael did not make this claim falsely; however it appeared to also be predisposed to his thin level of understanding of 'mathematics in context'.

Question two had an authentic use of context; however Michael did not take the opportunity to allow his students to explore this any further. The average human body temperature was not given and as such no standard of comparison could be made. Also there was no discussion on why the body temperature varied throughout the day and the significance of these fluctuations on Jana's well being. The curriculum requirement that data handling be engaged with critically, 'especially in the manner in which these are encountered in the media and in presenting arguments' was met with no sizeable correlation (Doe, 2003:11).

Of the twenty-one lessons observed, I have depicted the lessons that included teaching 'mathematics in context' to the largest degree. Having claimed that the only change that Michael had made to his instructional practice was the application of content taught to various contexts I observed eight of his Grade 11 Mathematics lessons. These observations revealed findings that attested to his claim, in that none of them supported any reference of application to context in any of the mathematics that was been taught.

This complete absence of application supported why Michael held the perception that his mathematical literacy instructional practice was different to that of his Mathematics instruction. Michael had made changes, however given that his starting point was so far removed from the mathematical literacy requirements these changes were only significant to Michael and not to the actual implementation of the mathematical literacy curriculum as intended.

What also featured prominently in these eight Mathematics lessons observed was Michael's attitude and expectations of the learners. In his Mathematical Literacy classes Michael was guarded against his interaction with the learners, and with the exception of the lively soccer discussion, which had no mathematical relevance, there was little if any 'teacher-pupil' interaction, providing in most cases the solutions to the learners before eliciting their responses. In his Mathematics lessons, Michael was by far more relaxed in his interaction with the learners and allowed for various discussions and debates on differing solutions. Furthermore in six of the eight lessons he challenged the learners with a ‘difficult' mathematical problem during the lesson. Such challenges were never forthcoming in any of the twenty-one mathematical literacy lessons observed.

Michael's differentiation in teaching and interacting with a class according to perceived ability was clearly evident. Why did the learner ability affect his instructional practice?

Synthesis of the lesson observations yielded the following deductions with regards to Michaels Mathematical Literacy instructional practice:

- no ownership of the curriculum,
- mathematical content was not only the focal point but predominantly the lesson,
- lessons were not sensitive to broader societal concerns,
- teacher-centered,
- attitude towards learners was guarded,

- recognition was not provided,
- no critical analyses of data or engagement with mathematical arguments,
- no use of indigenous mathematics contexts,
- creativity in solving problems was not allowed for let alone encouraged,
- instructional expectations of learners were low,
- surface teaching of mathematical 'life skills',
- contexts used were as chosen by textbook authors,
- instructional practice was based on a blueprint of years of experience.

These observations reveal that not only are Michael's understandings of the curriculum at a surface level but also that his instructional practice manifests itself at an even thinner level. His understanding of context is a superficial band-aid on mathematical content that allows him to perceive his teaching practice as both significantly different to his mathematics instruction and aligned with the curriculum document. This change has already established Michael's belief that he is implementing Mathematical Literacy in the way that is required .As such Michael does not question his practice nor seek intervention to change it any further. This raises two imperative questions pertaining to this study. How will Michael move from this surface understanding to a deeper level of understanding in the absence of a reflective instructional practice? What will allow for the reflection needed and thus for the deeper change required?

During the classroom observation time, I also looked at student workbooks and other documents relating to Michael's teaching of mathematical literacy. These were evidenced as follows:

7.7.3 Learner Work Books

Michael's mathematical literacy students work in hard covered books that are used to take down the daily lessons and complete their homework therein. These are studiously brought to every lesson and handed in every second week to be marked. Marking is done on an acknowledgement level indicating that the work has been done and there is no indication that work is corrected in any way.

With the exception of several pictures on worksheets that are pasted in the learner workbooks there is little other evidence of any use of context. Page after page is filled with formulae and mathematical calculations. The Data Handling section is thin on real life contexts that Michael claimed he would use in this section of his instructional practice. The work done on 'Number and Operations in Context' also had as its focus mathematical content and barring various calculations and manipulations of the compound interest formulae there are no authentic contexts in terms of application.

These two sections were the two that Michael expressed to believing could afford the learners with opportunities in engaging mathematics in contexts of relevance to their daily lives. Why had Michael not seized this opportunity to afford his students not only mathematical knowledge but skills and values that would benefit their lives in the way that he believed these learning outcomes could?

7.7.4 Use of Technology

In the questionnaire Michael had indicated that he <u>always</u> used scientific calculators, <u>sometimes</u> used spreadsheets and <u>often</u> used unspecified computer software. His observed instructional practice and evidence from the learner work books only validated his claim of often using a scientific calculator .The curriculum specifications include the use of computational tools taking a scientific calculator as a minimum but suggesting that 'where possible, learners should have the opportunity to use spreadsheets and other computer tools' (DoE, 2003:12). Such tools were not only available to Michael, but as was evidenced by his mark book, which was *Excel*, Spreadsheets Michael had the skills and knowledge to teach mathematical literacy using these tools. His response below defends the finding that Michael's' expectations of his learners were not analogous with the curriculum expectations of instruction providing for 'high knowledge and skills':

> *Perhaps next year I will take them into the computer room, for now we have to rather spend the limited time we have on using the calculator. These pupils struggle with doing basic operations on the calculator, how will they ever cope with learning to do a spreadsheet?*
> *He added:*
>
> *Not even the other mathematics teachers can do spreadsheet, but I am known as the Mathematical Literacy teacher. This is why I have to leave.*

It can only be assumed that Michael's responses on the questionnaire were an indication of his computer abilities and not those that he understood were required or necessary to be taught to his students. This was not because he believed that computer skills were not a necessity but because he believed that they were beyond his current students' ability. This behavior restricted his students from acquiring the necessary knowledge and skills that the curriculum allowed for.

His drifting from discussing computer skills to his retort on being known as the mathematical literacy teacher digs deep into Michael's perception of how mathematical literacy defines him as an educator. A revelation, that was not in the lines of inquiry in the propositions of this study, but kept manifesting throughout the duration of both the case studies and the snap shot interviews. The impact of wearing the 'Mathematical Literacy Educator' label on the implementation pathway of this curriculum may go far in explaining why the emphasis is on content and not on the process of content and context. Michael venerates mathematical content, the surrendering of, which may be perceived as a compromise to his 'status-identity' as a Mathematics educator. The veneration of 'naked' mathematics over 'mathematics in context' was also evident in Michael's assessment practice.

7.7.5 Assessment

Rating scales on the tests and worksheets were all of traditional marking and gave a numerical result out of the possible marks obtainable. The new rating codes and their relevant descriptors of competence were only reflected on the learners' reports and not on any of the assessed worksheets or tests. Rubrics were also absent and although collectively this evidence reflects more on Michael's instructional non-transformation to Outcomes Based Education it also go towards his understanding of the Mathematical Literacy curriculum.

The curriculum document states that,' rubrics require teachers to know exactly what is required by the outcome' (DoE, 2003:50) and as such the absence of engagement with designing rubrics robs Michael of a deeper understanding of the curriculum possibilities and as such purpose. The implications of this are limited opportunities in understanding and thus delivering the curriculum as per design.

The assessment tasks in the learner workbooks were also similar to his classroom instruction as to what was expected as an end product-accuracy of mathematical answers. The process of arriving at an answer was neither valued nor recognized. Pictorial depictions substituted for contexts, and application of knowledge and skills was at a level of routine procedure, with no evidence of complex procedure in neither application nor problem solving. These findings are discontinuous with those stipulated in the curriculum document and also with Michael's claims. Why Michael proceeds to implement the curriculum in this way forms the next section of this chapter.

7.8 Why does Michael implement the Mathematical Literacy curriculum in the way that he does?

Having portrayed Michael's understanding of the curriculum document and his observed instructional practice I will know provide evidence of what seems to shape and define his practice in pursuit of providing an explanation for the third research question to this study, namely, why do teachers implement this curriculum in the ways they do? In other words, what explains the implementation pathways followed by the mathematical literacy curriculum in real classroom contexts? The evidence for the response to this research question is obtained from the following research instruments; the Interview Schedules (Schedule C&D), Questionnaire Schedule (Schedule B), Document Analysis (Schedule F) and the Researchers Journal (Schedule J).

I begin this line of inquiry by evidencing the documents and records in Michael's possession.

7.8.1 Educator Documents and Records

Michael had in his possession copies of the Mathematical Literacy curriculum, the Assessment Guidelines, two Mathematical Literacy textbooks, the notes from the Mathematical Literacy workshop that he had attended, and a copy of an exemplar paper that he had downloaded from a departmental affiliated website-*thutong.org.za* An analysis of the textbooks and the exemplar paper revealed a high correlation with the curriculum design, particularly with regard to the use of context required in mathematical literacy pedagogy. The exemplar paper was also found to be in line with the Assessment Guidelines for Mathematical Literacy and the Assessment chapter in the actual curriculum document.

7.8.1.1 Mathematical Literacy Curriculum

Michael had indicated that he had read the curriculum document and had understood it to a large extent. Five weeks of observation revealed this claim to be limited to Chapter 3: Learning Outcomes Assessment Standards, Content and Context. What is more, is that even though Michael did refer to this part of the curriculum he focused mainly on the content. His concern was in whether he had covered all the necessary mathematics and showed little interest in any of the 'verbs', which represented the required competencies for the various learning outcomes. The section, in the same chapter, entitled Content and Contexts for the Attainment of Assessment Standards was also not referred to. Michael's perception was that if he taught the mathematics the students would be able to apply it to contexts that required it:

> *We cannot loose focus of the mathematics, the application will follow. In life this will vary, so it is so much more important to teach the pupils how to use formulae and equations so that they are not scared of numbers. If you look at the two textbooks you will see that the examples*

> *are different and I am sure that other textbooks would also have other examples but the mathematics required remains the same. It is this ability that will allow them to cope with subjects requiring mathematics at tertiary level. My focus is on the mathematics as prescribed by the curriculum, this is what is important and necessary.*

Michael's perspective on valuing 'Pure Mathematics' over 'mathematics in context' is favored by extensive literature[28] that argues against the use of real-life contexts that originate from the lived experiences of 'underprivileged' learners. Though, there is no evidence to claim that Michael's beliefs and understandings of the choice of context or the lack thereof is influenced in any way by this literature his inherent reverence of 'naked mathematics' significantly impacts on his instructional practice.

He is not delivering the mathematical literacy curriculum in the way that he does because he does not understand that he should be using contexts, he is delivering it in this way because he is consciously choosing content over context. Michael is doing this because of the value that he attaches to 'pure' mathematics. And, even though, this study is not an inquiry into the socio-economic utility of Mathematical Literacy in South Africa it is important to note that the interpretation thereof in terms of 'value' is appreciably influencing the implementation pathway of this curriculum in Michael's classroom.

7.8.1.2 Text Books

The use of the textbook, by Michael, in his teaching practice was not only extensive but often the sole source of instructional material. It was clear that he did not question the content of the textbook and used it not only in his daily teaching but also to vindicate him when challenged on what he was teaching. The following interaction with one of his learners, from observed lesson twenty, provides evidence of his dedication to the textbook teachings:

> Boy Learner: *Sir, this question is too difficult. My friend from the Mathematics class could not even help me. Are you sure it is in the syllabus?*

[28] See Dowling, P (1998) and Muller, J. (2000).

> Mr. Michaels: *It is not difficult; you just cannot do it. If your friend can also not do it then maybe he should also be in this class. Hands up, if you also found it difficult.*
>
> (Class does not respond.)
> Mr. Michaels: *You see, maybe you and you friend should be in a special class of your own.*
>
> (Walks up to researcher with textbook in hand pointing at the said question, and announces loudly :)
>
> Mr. Michaels: *This question is straight from a Grade 10 Mathematical Literacy textbook that you do not have. These people that write these textbooks know what they are doing, maybe your friend should write a textbook.*

This altercation with the learner does not only evidence Michael's allegiance to the textbook but also his attitude with regards to student's individual needs. Having acknowledged an awareness of 'math phobia' it is perplexing why he, more than likely, unconsciously chose to perpetuate it.

Michael's defense of the textbook would have also made more sense if he had selected the use of this over numerous others that were already available in the schools library at the time of this study. However, this was not the case. The textbook he mostly used (textbook one), which was also assigned to the students, was the first mathematical literacy textbook that the school had received as a sample copy from the publishers. His second textbook was similarly a free sample copy that had been distributed to FET High School. Further sample copies that were sent by the publishers were also available in the library. These had never been 'checked-out' as indicated by the computer records of the librarian. The reason for this was as Michael explained because the mathematics was the same in all the textbooks, but the use of context was not. As his focus was the mathematical content, he did not need to use the other textbooks as they could only provide further contexts, which he believed that the students who had learnt and understood the mathematics which he had taught would be able to apply these to differing contexts.

Although the textbooks had not been chosen, Michael did make choices as to what he was going to teach from them. Each chapter from 'textbook one' began with an introduction of the importance of the mathematics content that it dealt with in real-life application. The introductory examples were also predominantly 'mini-investigations' that integrated the content with the context. Michael, without fail, stripped the mathematics from the given contexts in both his explanations and lesson delivery. His instructional practice deviated from the curriculum in this main regard due to his reverence of the value of 'pure' mathematics.

7.8.1.3 Workshop Notes

Michael had two ring bound books with notes from the mathematical literacy workshop that he had attended earlier on in the year, the one dealt with the methodology of mathematical literacy and the other with exemplar questions. These were comprehensive documents that not only provided supplementary notes on the curriculum but also had extensive interactive exercises that allowed the delegates to engage with the curriculum on a relatively deep level. The activities in the notebooks had spaces in which the educators could record answers and perceptions. Several of the questions were pertinent to this study.

Michael in these spaces captured notes that showed a sizeable understanding of contexts relevant to everyday life. What was absent however in both Michael's and the workshop notes was coverage of how mathematical literacy was to be taught in terms of integrating content with context and not applying content learnt to contexts.

The exemplar tasks in the workbooks were also all contextually bound but again with no explicit provision that the teaching of mathematics should not precede its introduction into context, a stipulation of the curriculum, which can be found on several pages of the official document. An assumption is that this was implied.

However given that the nature of instruction for mathematical literacy is so distinctly different from that required in mathematics it would be expected that this would have formed a significant part in the workshop. Although it cannot be judged that the workshop that Michael had attended gave rise to Michael's surface understanding of teaching 'mathematics in context' it can be said that it had done little to contest this understanding. Having indicated that he had not found the workshop important, it was not surprising to find that Michael never referred to these notes. It begs the question that even if he did would the pedagogy required necessarily surface?

7.8.1.4 Exemplar Paper

Scrutiny of the exemplar paper that Michael had downloaded from the *Thutong* website revealed an assessment tool that was strongly aligned with the requirements of the curriculum. The questions were all contextually based, several in a South African context, and many relating to real life problems like obesity and budgets. The mathematical processes required in answering the questions required more than just the skill of doing mathematics, as some of the answers required critical interpretation and comparison. Michael valued this paper and indicated that he would be using it as the Grade Ten end of year examination.

> *I have a copy of the exemplar paper with its solutions, which is the best thing that the education department could have done. It shows what we should be teaching and how long the paper must be. I have looked at it and I am going to use it as the end of year examination .I do not need to worry about setting the paper at a standard that is too high or too low. If the pupils complain I will show them that this is what the government expects. One less paper to worry about.*

However the value he had ascribed to this paper was not as a result of his own analyses of the paper but rather that it was the example that the education department had made available to mathematical literacy teachers. This was evidenced in the fact that at the time of the study he had not worked through the exemplar paper as its memorandum had also been made available on the website. There was also no indication that he would be looking to work through the paper at any later stage. Once again Michael had not taken an opportunity that he was presented with which would have allowed him an inquiry on his seemingly already set understanding of the mathematical literacy curriculum. The reason for this was once again embedded in his belief that he had understood the curriculum document and that he had already managed to implement this curriculum as was required.

How he had arrived at this understanding can only be based on his belief that he understood the mathematical content which he had to teach. This ability, he felt distinguished him from other teachers who had never before taught or learnt Mathematics of Finance and Statistics. Michael had been taught this as a student doing Additional Mathematics in his Grade Twelve year.

7.8.2 Introducing Mathematical Literacy to FET High School

As mathematical literacy was the mandatory alternative to core Mathematics, Michael's Principal and Head of Department followed the education department requirements by taking the decision that it would be offered at FET High School as from the beginning of 2006.Michael was told that he would be teaching two classes of Grade 10 Mathematical Literacy near the end of the previous academic year.

He was not involved in these discussions and was unaware as to why he was the only educator in his department told to teach this new subject. At that the time he was given the curriculum document and one of the sample Mathematical Literacy textbooks that the school had received which he subsequently proceeded to use as it was also the textbook that his student's made use of.

Michael admitted that he never took either home, and only began to read both the textbook and curriculum document once his first mathematical literacy class arrived. His lack of interaction with the subject prior to its implementation was a result of the low level of mathematics that Michael believed this curriculum to require. An understanding he had arrived at because of the students that would be taking this subject. That is, students who either were failing mathematics in Grade Nine or were going to pursue tertiary careers that did not require core Mathematics.

Prior to the implementation of mathematical literacy at FET High School, Michael had had no other interaction with teachers on the topic of mathematical literacy. And, other than the workshop that Michael had attended, this lack of communicating about this new subject had continued, at least, into the first eight months of its introduction.

The weekly departmental meetings focused on the FET core Mathematics curriculum, as did the cluster meetings that Michael attended every three months. Mathematics was always the point of discussion Michael said, not because there was no opportunity to discuss mathematical literacy but because the other educators in his cluster also felt that "it was going as well as it could be considering how weak the pupils actually are".

7.9 Learner's Views

As this study had an explorative design I asked Michael for his permission to look into how his students were experiencing this new curriculum, as this could go towards providing tacit insights into his learners own views on their ability and engagement with mathematical literacy, which may be a result of mathematical instruction that they had been receiving.

Michael had no concerns with regards to my request and offered me twenty minutes of one of his lessons near the end of the research period to conduct an exploration on his students' views on mathematical literacy. The students received a single question, namely, how is Mathematical Literacy this year different to the mathematics of the past, and were told that it was optional as to whether they wanted to respond to it or not. Of the thirty-two learners all of them handed me a reply at the end of the lesson.

I provide a sample of these reactions that most pertain to this study in terms of Michael's responses, in order to further provide evidence for perhaps why he has come to understand his student abilities in the way that he does. Inevitably, these perceptions of Michael's inform his delivery and ultimately play a role in how Michael proceeds to implement mathematical literacy in his grade ten classroom.

7.9.1 Learner Transcriptions

It is different, last years Maths was very easy, and this year it is kind of difficult. It is a natural thing, some people can and others can't.

It is different, it seems so much harder, and I feel pressured because I no longer have the choice, as to whether or not I want it as a subject. The maths is supposed to be on a lower grade to normal maths. It is not, we are really struggling. What I want to do one day does not require all this frustration that maths is causing.

It is not helping me one bit. It is hard and I do not understand. I left Mathematics in order to have an idea of what maths is about. Now I am even more confused and scared of failing.

It is not real maths, but it is still difficult.

No use. Remove maths literacy because we do not understand.

It is supposed to be easy and straightforward. Some were born intelligent, our class was not.

It is the same, you do sums. It is more difficult than last year. Maybe you should ask the Mathematics class they are bright.

It is difficult and a waste of time. I would rather be in English; there I do not feel stupid.

It is so hard, this IS NOT FAIR.I am embarrassed to tell people that I find this lower grade subject hard.

It is hard but at least it teaches me to do finance calculations because I intend to become a Chartered accountant.

Some of us are bad in maths and this was supposed to be easier, it is NOT. I am so stressed because I will fail the year if I do not pass maths literacy. I will never pass, I am not natural at maths.

Of the thirty-two respondents there was not a single indication that the learners found the instructional practice of mathematical literacy different to the mathematics instruction that they had received in the past. For these learners the only difference worth mentioning was the level of difficulty. What is more their self-perception of their mathematical ability was not only low but of an emotionally self-degrading nature.

On reading the responses Michael showed no sensitivity to these poignant features and proceeded to remind me that these students had a past history of unsuccessful mathematical achievement. He also stipulated that this is one of the main reasons why he focuses only on the 'basics'. Michael's perceptions of who can and can not do mathematics seemed enshrined in the students past histories which he evidently believed could not be written in any different way in the future. This is an important finding to this study as it impacts on the level of delivery of Michael's instructional practice which ultimately affects the implementation of the curriculum as designed, that is, with its requirement of affording high levels of knowledge and skills.

7.10 Summation

To sum up Michael understood the Mathematical Literacy curriculum in terms of teaching mathematics and then, time permitting, applying the mathematics taught to textbook assigned contexts. He was also influenced strongly with what he perceived as low learner ability which he did not believe could be changed appreciably and as such focused on what he called "teaching the basics". This understanding was not only discontinuous with the curriculum objectives but was also of disturbing significance to his students.

Moreover, Michael implemented mathematical literacy in a way that was ingrained in his beliefs and practices about the nature of mathematics from the past. These included a reverence of 'naked' mathematics that expressively defined Michael as an educator. The label of 'Mathematical Literacy Educator' seemingly threatened this identity and it can go towards comprehending why Michael did not want to relinquish nor question his traditional instructional practice. For by aligning it to the past he ensured that he was no 'less' of an educator than he had been as a Mathematics educator.

In Chapter Eight I will pursue theoretical and empirical explanations for the questions raised in both Chapters Six and Seven through the analytical lens of the conceptual framework provided for in Chapter Four.

CHAPTER EIGHT

Probing the relationship between theory & practice

'The question of implementation is simply whether or not a given idea, practice or program gets "put in place"[29]

8.1 Introduction

In previous chapters, I described how and why Mathematical Literacy was being implemented in the way that it was in two South African schools. My research findings, resulting from an exploratory design, indicated that implementation was discontinuous with curriculum intentions in terms of practitioner understandings of purpose and pedagogy, and those teachers felt that their professional status and identity as mathematics educators was somehow under threat.

My observations suggest that the implementation of mathematical literacy is in difficulty, not because politicians and education department officials are deluded about the realities of the actual classroom situation in the majority of South African schools, but because this mandatory Mathematical Literacy curriculum is often advanced as a silver bullet to the mathematics crisis in this country without sufficient strategies, or insights into required strategies, to support those responsible for its actual implementation. Simply put, the new mandatory Mathematical Literacy curriculum does not have a strong theory of action that is suited to its broader purpose and its implementation context.

This final chapter will juxtapose the research findings with the extant literature on curriculum change and will further analyze the evidence from the two case studies through the lens of the deep change conceptual framework presented in Chapter Three. The analysis will also provide for reasons as to why this study advances new knowledge beyond what is already known about the implementation of mandatory curricula in

[29] Fullan (2001) Implementing Change at the Building Level. Paper prepared for W.Owings and L.Kaplan (Eds.). Critical and Emerging Issues in Educational Leadership. *www.fullan.org*

developing countries. Having previously argued for research that is specific to the work mathematics teachers do, (Shulman 1986 in Price & Ball 1997), the empirical evidence gathered in this study fronts the expansion of this argument to the limited knowledge base in developing countries. This chapter concludes with a discussion on the implications for future research and the significance of this study.

The question as to why some mathematical reforms flourish and others fail has been extensively researched (Burgher, 2000; Cockroft Report, 1982; Cohen, 1990; Humenberger, 2000; Plowden Report, 1967). The perspective I offer, based on an analysis of the new Mathematical Literacy curriculum in South Africa, seeks deep change in the behaviours of teachers. This change is required not only in pedagogical content knowledge, but also in understanding the nature and value of mathematical literacy. It proffers evidence as to why the 'status-identity' of mathematical literacy teachers needs to be explicitly defined in both the personal and public arenas before any of these changes can begin to occur or be expected.

Such change is not only complex but also very personal. I conclude that unless a radical transformation in terms of accepting and forming new identities occur among teachers given the responsibility of implementing this educational change, mathematical literacy cannot but sustain traditional instructional practice. As this exploratory research was conducted in the first year of implementing the new curriculum, the findings are tentative but indicative of future problems in practice. It is of course unrealistic to expect that the deep change required will be evident so early on in the implementation process as the requisite changes in pedagogy and acceptance of new teacher identities will require time to develop and unfold even under optimal conditions of reform.

I argue that if inputs that can trigger this change, in the form of appropriate staff development programmes, and new and public discourses on what it means to be a Mathematical Literacy teacher, are not provided for early on in the implementation process, teachers will settle into teaching this curriculum falling back on knowledge and beliefs already entrenched in their instructional practice. And they will do so in ways that do not embrace this reform as intended by the curriculum policy.

Drawing principally on Michael Fullan's work, and in particular his theory on 'deep change', the teacher data gathered from the two case studies revealed the following:

- that teachers had a very thin understanding of the mathematical literacy curriculum in terms of the required pedagogy, and also the subjects ontological and epistemological nature;

- their instructional practice was neither aligned to the curriculum nor to their claimed beliefs and understanding;

- collaboration and reflection was not evident in their teaching and learning of the curriculum;

- there was no collective moral purpose in their schools;

- and that teachers' old 'status- identities' as mathematics educators was under threat.

Most of these observations are commonly documented in the literature of educational change. What is not as widely found in scholarly text however is how the threat to the 'status-identity' of experienced teachers can actually preclude them from engaging with a curriculum policy in ways that allow for successful implementation.

The overriding insight gleaned was that teachers do not engage with the curriculum deeply or reflect on their mathematical literacy instructional practice because they feel that it further lowers their status as mathematics teachers. This is because they believe that to be told to teach mathematical literacy questions their mathematical ability, and thus to question and reflect on one's understanding of this curriculum is to somehow concede that this perceived lowered 'status- position' in the mathematics department is suited to the teacher.

8.2 Thin and Disconnected Levels of Understanding

8.2.1 Teaching Mathematics in Context

Michael and Norman were both found to have a limited understanding of the curriculum requirements. This understanding varied in degree with both educators having a relatively deep understanding of most of the content but no other features of the curriculum, particularly with regards to purpose and pedagogy. The evidence from this study indicated that Michael and Norman used a traditional way of teaching mathematics, which was similar to that they had received as secondary school learners. This traditional way included the teaching and emphasizing of mathematical content .For Norman the use of context was a mandatory 'band aid' without any significant attachment to the pedagogical philosophies of the curriculum; while for Michael the use of context was an extension to be pursued if, and only if, time permitted. Michael stated that he taught the "basic skills first" and then extended these to real life applications, the evidence of which was lacking in his observed instructional practice. Both teachers also felt that this method of focusing on the mathematical content provided a strong foundation in developing the mathematical skills required by the curriculum and that without consolidating the basic mathematical content they could not move onto exploring and applying what was learned to contexts that were of relevance to their learners' lives.

The curriculum is explicit on what the required pedagogy should be[30], and does not include that content should be taught first but rather that the mathematics content should be taught and explored through the use of relevant contexts. By contrast, most of the observed lessons of Michael and Norman's instructional practice were indicative of lessons that provided instruction on the use of algorithms which only provides for

[30] (Doe, 2003:42): The approach that needs to be adopted in developing Mathematical Literacy is to engage with contexts rather than applying Mathematics already learned to the context. Research done internationally and in South Africa confirms this approach for young people as well as for adults.

instrumental understanding (Skemp, 1971), which is at the lowest level of the three philosophies of mathematics as psychological systems of beliefs[31] (Ernest, 1998), and not the relational understanding that is required by the Mathematical Literacy curriculum. In reality, it is not likely that mathematical literacy is going to be implemented as intended by educators who do not understand the nature of mathematics. This dimension of the curriculum was not discussed in the available official documents and was also not part of the preparatory activities to ease teachers into the teaching of Mathematical Literacy. And, even though Michael did recognize that he was not aligning his instructional practice to the curriculum intentions by providing conceptualized questions and problems he was unaware as to how this delivery was recommended by the curriculum policy to take place.

Similarly Norman had also no clear understanding of this instructional feature of the curriculum. Michael's thin understanding was that this curriculum was different to standard grade mathematics in the sense that all it required was "a matter of adding a context". The distinction between mathematics and mathematical literacy is principally not a distinction in level, but a distinction in kind. The old mathematics higher grade was at a higher cognitive level to mathematics standard grade in the sense that standard grade was a watered down version of higher grade. There was very little sophistication in standard grade mathematics. In mathematical literacy however, the curriculum intention both explicit and implied, is that simple mathematics be used in sophisticated ways. Thus the cognitive demand in mathematical literacy is much greater than the cognitive demand in the old standard grade mathematics. Michael and Norman’s lack of understanding of this, may also have be influencing their beliefs about the status of their work.

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[31] Ernest (1989) conjectures that three philosophies of the nature of mathematics are hierarchical. Instrumentalism is at the lowest, involving knowledge of mathematical facts, rules and methods as separate entities. At the next level is the Platonist view of mathematics, involving a global understanding of mathematics as a consistent, connected and objective structure. At the highest level, the problem solving view sees mathematics as a dynamically organized structure located in a social and cultural context.

Norman understood the required pedagogy as "you teach the content and then add the context". Michael and Norman had claimed to read the curriculum and their belief that they understood the curriculum to a large extent emanated from their claimed understanding of the content. This limited engagement with the curriculum reveals a superficial view of how these educators understood and perceived this new curriculum, mainly that the Mathematical Literacy curriculum was a mathematics curriculum with different content, with the occasional addition of context as an illustration of the importance and frequent occurrence of mathematics in everyday life.

This dissection of content and context by both Norman and Michael was mostly based on the reverence they both had for 'naked' mathematics. The privilege afforded to algorithms directed the implementation pathway with which both educators conducted their instructional practice. The skills and values associated with the curriculum were subjugated into a position with little value, and even though as Kay holds "appropriateness of method [is] highly circumstantial and generally unpredictable", (in Thompson, 1984) an awareness of the method required was neither evident in Michael or in Norman's practice.

For both educators it can be argued that this understanding they had of the curriculum was for the most part centered on their perception that the section in the curriculum focusing on the content was of primary importance, which in turn was for the most part a result of their own experiences in learning mathematics. It was however also reflected in their belief that teaching mathematics in terms of formulae and algorithms was less threatening to their 'status-identity' as 'intelligent and capable' mathematics teachers. So even though there is a need for these teachers to acquire content knowledge that is different to that which they received in secondary and tertiary studies, and that differentiates between numeracy and mathematics (Steen, 2001), there is a similar need to recognize how perceptions of the requisite knowledge positions the status of these teachers in both the public and private domains.

This shell of understanding of the curriculum features of required pedagogy, which can be captured in 'teaching mathematics in context', was further found to apply not only to their pedagogical styles but also to their thin use of contexts relevant to learner lives. The use of context is expounded on in the literature with theories and evidence as to what is of importance and danger to learners' learning (ILEA, 1983, Broomes, 1989). Such an analysis would however assume that Michael and Norman were consciously selecting the contexts that they were using, which during the classroom observations was found not to be the case.

The curriculum stipulation that the contexts should be 'rooted in the lives of the learners' is in keeping with Freudenthal's RME theory that 'mathematics must be connected to reality, stay close to children and be relevant to society in order to be of human value'. And even though RME theory has several proponents highlighting its limited[32] use in developing democratic competence which is one of the main purposes of the Mathematical Literacy curriculum, as an ideal entrenched in the curriculum it was explored and found to neither be pursued nor engaged in with any significant depth by either teacher.

Michael and Norman recognized the discrepancy between their instructional practice and the curriculum policy only in terms of quantity that is, not using context as often as they should. However what they were both unaware of was that the curriculum did not prescribe context as a follow on to content but rather as a process. Given their understanding of the required pedagogy as thin, even if Michael and Norman had more time a resource they both stated they required, there was no indication that they would implement the curriculum as intended.

When they did use some semblance of context it was inevitably that which was offered up by the textbook and at no time reflected either context of elicited interest of the learners nor context that was consciously chosen as an empowering future benefit to the

[32] See Cyril Julie, 2004. Can the Ideal of the Development of Democratic Competence Be Realized Within Realistic Mathematics Education? The Case of South Africa. *The Mathematics Educator*.14 (2) 34-37.

learners. This absence of selecting appropriate and relevant contexts was mostly based on the teacher's assumptions that once the mathematics had been taught and learnt it could be applied to contexts that required it.

Using the examples that the textbook offered was in one way less work for the two teachers but it was also used as given because the two teachers clearly believed that the application to other contexts would follow. This transfer of mathematics to other contexts and the 'everyday' lives of students cannot however simply be expected as it is widely recognized as a student and teacher difficulty (Michelsen, 2005, Boaler, 1993)

This surface use of context furthermore also limited the opportunities that Michael and Norman presented to their learners: as Skovsmose (1998:419) argues:

> It is essential to consider students' interest. But the interest cannot solely be examined in terms of the background of the students. Equally important is the foreground of the students.

It is this "foreground" that is essential for the learners, if a new curriculum is to play any role in raising the unacceptably low levels of mathematical literacy in this country. For as Stigler and Hiebert (1999) suggest, it is the teaching methods and not the teachers *per se*, that is a critical factor in promoting and improving student learning.

The deep change required in their instructional practice needs external strategies and interventions that promote the required depth of understanding. The National Numeracy Strategy (1999) in the United Kingdom has included intervention in training teachers through observing other 'Leading Mathematics Teachers' that turns the delivery of the curriculum into concrete lessons that other teachers attend and observe. Such demonstration of lessons by teachers that have a deeper understanding and appreciation of the curriculum in a developing country become even more profound as they allow for collaboration, hands on experience of what is actually required, and learning a curriculum in a way that they were never taught. An opportunity, that Paulo's (1995) concurs with as being instrumental in learning and understanding the requirements of new mathematics reforms. Furthermore it supports the setting up of learning communities were teachers can see best practice teaching and in doing so open themselves up to reflection and a deeper level of understanding the curriculum intentions. Fullan notes, "Clearly, deep pedagogy and deep learning cultures feed on each other" (Fullan, 2004a: 12).

Price & Ball (1997:661) reason that making change in mathematics presents unusual challenges for reasons including, that "mathematics reforms are far from a blueprint of action, a plan to be implemented" and secondly mathematics teachers "formal education is typically thin, and they often do not feel mathematically competent or confident". The surface change which was a common feature in both Michael and Norman's classrooms cannot be attributed to a 'thin education' as they were both qualified mathematics educators even though their levels of qualification were considerably different, nor can it be attributed to a lack of self confidence in subject knowledge. It would be more accurate to argue that the surface understanding occurred because these two educators had not constructed a sophisticated meaning of the change process required by the curriculum (Fullan, 1991). Such sophisticated meaning can only be arrived at when a fundamental change in the way that teachers think and behave occurs. Fullan (1995:23) explains this as follows:

> It is no denial of the potential worth of particular innovations to observe that unless deep change in thinking skills occurs there will be a limited impact... [The] main problem in education is not the resistance to change, but the presence of too many innovations adopted uncritically and superficially and on an ad hoc fragmented basis.

Given the caveat that perhaps it is too soon to expect deep change in thinking for both Michael and Norman, it is pertinent to remember that unless this surface level understanding is not disturbed, expected changes will not occur. Neither Michael nor Norman expressed any real uncertainties or queries as to whether they were implementing the curriculum as intended. The lack of such tensions in their beliefs on the nature of mathematical literacy and hence their understanding of the required pedagogy of the curriculum, is indicative that these two educators had not as yet engaged the core issues of the curriculum. Ernest (1989) clarifies this as follows:

> Mathematics teacher' beliefs have a powerful impact on the practice of teaching'. During their transformation into practice, two factors affect these beliefs: the constraints and opportunities of the social context of teaching, and the level of the teacher's thought. Higher-level thought enables the teacher to reflect on the gap between beliefs and practice, and to narrow it...The social context clearly constrains the teacher's freedom of choice and action, restricting the ambit of the teacher's autonomy. Higher level thought, such as self-evaluation with regard to putting beliefs into practice, is a key element of autonomy in teaching.

The absence of 'higher level thought' restricted the teachers from engaging with the curriculum on a deep level. This was evidenced in the teachers' understanding of the purpose of the required reform. Contexts were also found to play a commanding function in arbitrating the curriculum delivery. For, the teaching through the medium of context was extremely difficult not only because it was different to their traditional mathematics instruction but also because time available was insufficient.

Their response to curriculum policy was further a function of their understanding that the new curriculum undercut knowledge at the expense of process. This challenges mathematical literacy stakeholders not only to hold practitioners (practice) up for scrutiny but also the curriculum policy. It cannot simply be assumed that the policy is right and that the teacher's simply cannot make sense of it.

8.2.2 Purpose and spirit of a reform

When radical curriculum reforms are pursued and expected, a deep understanding of the purpose of such curricula is taken as a prerequisite in ensuring successful implementation. Extending on this, when transformation is addressing past equity issues, such as those in mathematics education in South Africa, understanding the purpose is deepened and broadened in not only understanding the reform intentions but also embracing the 'spirit' of the reform. Collectively this enlists the need of understanding both academic and moral purpose.

Norman and Michaels backgrounds although had many dissimilarities also had several poignant similarities. Norman was born and educated in Zimbabwe, and while growing up he lived through the transition of the end of racial discrimination in his country of birth. Michael was a South African Cypriot who as a secondary school learner served to defend the apartheid government only to find himself within the same decade living and educating in a country that went through transformation, in many ways similar to that of Norman's. Both these educators had lived through times were suffering and human atrocities were rife. They had also both witnessed and experienced education systems that were not only hugely transformed from the day that they had attended secondary school but also very different in equitable or the attempt for equitable delivery. As mathematics educators they had both experienced in their teaching careers the low levels of mathematical proficiency in both the students which they taught and the Grade Twelve mathematics results for many a year. It would thus be expected of them to be able to attach some sense of deep meaning as to what the purpose of this new reform entailed. And yet, both Norman and Michael had a thin and disconnected understanding of what the purpose of this curriculum was.

The reason that the reform was called for was not questioned and it was held by both that it was the alternative to the old Standard Grade Mathematics in the sense that the education department in getting rid of differentiating levels in all the subjects recognized that not all learners could do mathematics and as such had to offer an alternative. What was also similar for both the case studies is that they were aware of the unacceptably low levels of mathematical literacy in the country, the evidence of which was produced by the questionnaires.

However there was no deep link for either of them between the purpose they could recognize in the questionnaire and the purpose that they were capable of explaining during the interviews, or delivering in their classrooms. Their perception was a reflection of a poorly understood curriculum document, in terms of nature and pedagogy, and also a thin understanding of the purpose of the reform. Hill (1997) suggests that before accepting that change is necessary, teachers must believe it is worthwhile to put time and effort into learning new ideas, be able to understand them, and be aware of and dissatisfied with their current conceptions. Neither Norman nor Michael expressed any dissatisfaction with the old standard grade curriculum that they both believed the new Mathematical Literacy curriculum had replaced.

Norman, as mentioned, felt that because the education department had done away with all standard grade curricula they had realized that they had to provide an alternative to mathematics, as they were aware that not all learners were capable of doing the core mathematics curriculum. His responses were also confused for in one instance he stated that Mathematical Literacy was more beneficial to the learners than some of the mathematics in the ordinary curriculum but did not hesitate to add that he was unsure as to why it had replaced the standard grade curriculum which he believed may be re-introduced after the revision period," [L]ike I said we are all confused why this subject has been introduced, but I do see that it can have real life application". Similarly Michael's perceptions also revolved around the new curriculum as a substitute for the old standard grade curriculum:

> *Because the government has done away with standard grade in all the subjects. In maths this is not possible, because they cannot all do maths. So they have provided an alternative for these children that struggle with normal mathematics. It is the government's way of making sure that every child has some maths even though it is not real maths. If taught properly it can be useful because at least these children can make sense of simple maths that they encounter in their lives*

This perception of Michael and Norman limited their engagement with the curriculum document in that it allowed them to continue with a similar instructional practice as that with their past direct and/or indirect experiences of the standard grade curriculum.

This 'falling back on familiar routines' is widely evidenced but not as widely theorized as to why it occurs. This may occur because teachers do not embrace the 'spirit' of the reform, not because they choose not to, but because they do not have a deep understanding of what it is that they should be embracing. On the surface it may appear that Michael and Norman are relying markedly on superficial resemblances amid their current practice and the reform ideas, and so the innovative aspects of the reform are eluded (Spillane *et al*, 2002). However the question is why do they rely on these resemblances? It would be naive to postulate that these educators have had such an intensification of work that they selectively choose to rely on the similarities, as it requires less work and less change.

Michael and Norman continue to deliver a new curriculum in a similar way as they did with the old standard grade mathematics not because they consciously choose to believe that standard grade mathematics was a better curriculum nor for the sole reason that they are overworked, but because they do not comprehend the massive negative implications that standard grade mathematics held for the majority of the countries learners. As Aarnout Brombacher (2004: 5) emphatically states:

> That we should never again have a subject such as Mathematics SG with all the apartheid baggage that goes with it is not an issue here. Mathematics SG served nobody well.

What is an issue here is that Michael and Norman become aware of this failure of the old system and curriculum and recognize why a change is required. Not because what they have been doing in the past was wrong but rather that something different and new is required for the future. The awareness of the purpose and philosophy that underpins the Mathematical Literacy curriculum can be taught and as such becomes a matter of staff development, what is harder is the acceptance of the philosophy, which in this developing country includes, as a part, the matter of 'collective moral purpose'.

'The moral imperative means that everyone has a responsibility for changing the larger education context for the better' (Fullan *et al*: 2004b: 2). In FET High School and East Rand High School the responsibility lies solely on the shoulders of Michael and Norman. Their departmental heads and colleagues neither engage with nor inquire into the mathematical literacy beliefs and instructional practice of these two educators and nor do the principals of their schools.

The theory of action mentioned earlier needs to provide staff development not only for the educators but their department heads and principals. Such an approach, which was research and evidence based, was used in Ontario where principals received training on the *Expert Panel Report on Mathematics*, which was found to be of invaluable support to the staff entrusted with implementing the new reform (Campbell *et al* 2006). Developing moral purpose requires a deep belief in that what you are doing is not only of value but is also valued. Neither sign that was evidenced in either Michael's or Norman's support environment. A sign that would also go some way in changing the perception of the status of the curriculum, at least to begin with, within the confines of their working contexts, which in turn can start to relieve the threat that these educators feel towards their teaching identities. For if their colleagues believe and understand that what the two teachers are teaching is of value, they themselves can start to believe and understand that what they are teaching is valued.

Michael and Norman were found to value teaching and even though Michael conceded that this was not his first career choice, his responses were often indicative of a teacher who valued the work that he did. Statements such as " I love the classroom"," teaching mathematics is what I love"," I felt I could contribute so much to the pupils of this country", and " I am not saying I will not do my best, I will do all that I can to ensure that my maths literacy pupils pass" show that Michael's teaching was driven by a desire to assist learners in the teaching and learning of Mathematics. Likewise Norman expressed feeling very rewarded when several of the learners that he taught, at the inner city college in Johannesburg, passed Mathematics that had never before done so. His insistence that he would not lower his teaching standards despite numerous complaints and a lot of pressure from the parents also go towards showing up character traits of Norman's that lend themselves to a similar interpretation to that of Michael.

What is now required is a deep understanding of the purpose of the Mathematical Literacy curriculum which in turn may lead to a deeper ownership of the curriculum through a recognition of it's value in everyday numeric life. Owning a curriculum implies that the teacher believes in the reform and hence the new curriculum and as such finds it easier to take up the necessary change in instructional practice and beliefs. What the findings of this study reveal is that this aspiration is not being translated into outcomes as it is hindered by a thin level of understanding of the broader purpose of the transformative nature of mathematical literacy. The illumination of which is clearly a responsibility not of the implementing agents like Michael and Norman but the collective leadership that lies above them. A leadership, that has not comprehensively included strategies that account for and make explicit the broader purpose and 'spirit' of the intended reform. Understanding the 'spirit' of a reform has been found to be habitually not understood and/or neglected in its entirety (Chisholm, 2000; Spillane, 2000). Strategies must also make explicit the goal of 'raising the bar and closing the gap' with respect to "numeracy, which is on the agenda of many countries whose performance is unacceptably low" (Fullan, 2005b: 4), such as those in South Africa.

In developing countries this has an explicit connotation in that deep transformation in the teaching and learning of mathematics relevant to everyday life can start to take place if and when educators believe and understand that what is needed goes beyond their interpretation of textbook content. Michael and Norman need to revisit on what it means to them to be mathematical literacy educators and their head of departments and principals need to acquire a deeper sense of what the introduction of mathematical literacy means for their schools and the community at large.

Such transformation requires the accepting that the teaching of mathematical literacy is needed, and is further enhanced through the recognition that 'teaching at its core is a moral profession' and as such that teaching mathematical literacy in South Africa may be a 'moral imperative'. This establishes that understanding the purpose of a new reform curriculum is of importance. It however does not establish that this understanding will lead to the required change, as the workload that it may entail may be more than teachers are willing to adopt as an effect of believing that what they should be doing is not as valued as what they were doing (teaching mathematical literacy as opposed to teaching mathematics).

8.3 Inconsequentiality

Both teachers expressed a love for teaching and a desire for their learners to achieve. Michael spoke of the initial sense of how important it made him feel when told he had so much to offer learners during his interview for a teaching bursary. Both these educators however at the time of the study showed distinct signs of burnout and frustration that significantly impacted on their delivery of the curriculum. In a comprehensive study on teacher burnout Farber (1991) exposed the demoralizing outcomes when educators started to believe that what they were doing no longer made a difference, he called this the escalating "sense of inconsequentiality".

It was a similar 'sense of inconsequentiality' that Michael and Norman were experiencing in teaching mathematical literacy. They were unsure as to why they were the teachers told to teach mathematical literacy, and were as unsure as to why the less experienced and less qualified teachers had not been told to do so. This was a concern, for neither the teachers nor the wider learning communities that they found themselves to be part of, at the time of the study, valued the Mathematical Literacy curriculum and the possibilities that it provided for, as perceived by the two teachers.

Michael and Norman taught Mathematical Literacy because they had to and not because they wanted to. How are such teachers to come to believe and understand that what they are doing and have been made responsible for is valued? For curriculum stakeholders this is a thought-provoking message. Teacher education programs and teacher development programs should not only enable teachers to develop a deep understanding required to meet the complex demands of a compulsory curriculum but also provide evidence for what they are doing both matters and is valued by the broader educational landscape. Teachers must develop understanding through acquiring knowledge on the need of the new reform by been exposed to and engaging in the purpose of the reform. Teachers must develop a sophisticated pedagogical knowledge of teaching mathematics in context, that together with a deep understanding of the need and nature of the reform enables them to represent subject matter in multiple and meaningful ways that connect with the purpose and scope of the curriculum and not only the content.

It is also a powerful message in terms of offering rewards. For to bring about this momentous change, a reason that benefits the educators and is more concrete than moral imperative needs to be introduced. Once teachers want to teach mathematical literacy only then can the deeper moral purpose of why they are teaching it become entrenched in their belief systems. If such impetus is nurtured then the rewards become secondary to the bona fide quest of what was once a noble practice and as such gain what Fullan (2003:3) refers to as personal purpose:

> Personal vision comes from within. It gives meaning to work, and it exists independently of the organization or group we happen to be in. Once it gets going, it is not as private as it sounds. Especially in moral occupations like teaching, the more one takes the risk to express personal purpose, the more kindred spirits one will find. Paradoxically, personal purpose is the route to organizational change.

How will Michael and Norman acquire this personal vision and consequently personal purpose when both at the time of the study were feeling a threat to their 'status- identity'? This finding adds to the literature for even though construction of teacher identity is extensively written about (e.g.Kalmbach Phillips, 2002; Estola, 2003; Soreide, 2006) there is a lack of empirical evidence on how threats to the 'status-identity' of an academic discipline impacts on vision and understanding of a reform curriculum.

8.4 Threat to Status of Teacher Identity

Teacher identity with regards to curriculum recommendations is an area that has been explored in the literature in terms of requirements and ability to fulfill either explicitly stated or implied curriculum and policy roles (Jansen, 2001; Soreide, 2007). Although this is an area of interest and concern for implementation of curricula, what emerged in this study is something variably different that was neither expected nor explicitly pursued in the original research questions. My main finding is that educators in South Africa that are qualified as mathematics teachers are feeling a threat to their 'status -identity' by being identified as the mathematical literacy teachers.

In the curriculum document for Mathematical Literacy (DoE, 2003:5) 'The Kind Of Teacher That Is Envisaged' is given as follows:

> All teachers and other educators are key contributors to the transformation of education in South Africa. The National Curriculum Statement Grades10-12 (General) visualizes teachers who are qualified, competent, dedicated and caring. They will be able to fulfill the various roles outlined in the Norms and Standards for Educators. These include being mediators of learning, interpreters and designers of Learning Programmes and materials, leaders, administrators and managers, scholars, researchers and lifelong learners, community members, citizens and pastors, assessors, and subject specialists.

This description of the South African teacher mainly revolves around the expectation that teachers are overtly expected to be part of transformation in the country and also life long learners. This duality in roles as moral agents and academic scholars does not provide however for how such roles are actually valued in domain specific contexts.

Both Norman and Michael were explicit in their need as to how they were to be referred to as educators, neither wanting to be known as a mathematical literacy educator. This unexplored field of what mathematics teachers in South Africa and perhaps other developing countries view themselves as, in terms of status held, is paramount in understanding why they do not engage in the curriculum document with any depth. As qualified mathematics teachers, they see it as subordinating themselves and their knowledge if they do not state that they can do and understand the curriculum. Somehow by questioning the curriculum they believe that their subject knowledge is been questioned and as such their identity as mathematics educators. What is clear is that these qualified mathematics teachers that have taught and teach Higher Grade senior phase Mathematics believe that they hold a status superior not only to other learning area educators but also to other mathematics educators who previously taught and teach Standard Grade Mathematics.

It is not difficult to understand why. In a country were the shortage of mathematics educators is widely known and reported not only in the literature but in the daily media these two educators have come to believe and accept a so called 'superiority' that has become deeply entrenched in their identity and in the pride this gives them in stating that they are mathematics educators.

Norman stated that he was perplexed as to why he had been asked to teach mathematical literacy as he believed that he should only be teaching mathematics as that is what he was qualified to do. He expressed that the parents would think that he was 'doff' and that is why he was told to teach the subject. What is more, the learners at his school also held a similar impoverished view of educators teaching mathematical literacy. This is evidenced in Norman's following expression:

> *In the beginning of the year my class asked me what I had done wrong to be given the mathematical literacy class to teach. As a matter of fact one of the girls asked me why I was being punished. Another asked if it was because the other mathematics teachers in my department were brighter. They were distinctly under the impression that I was weaker than the others.*

Similarly Michael also inquired as to why he was told to teach mathematical literacy. He was academically the most qualified member of his five teacher department and with seventeen years of teaching experience was also considerably more experienced than the rest. In his view this qualified him an exemption from teaching mathematical literacy, which he believed should be done by educators that previously taught Standard Grade Mathematics, something that he claimed he had never done.

Michael's classroom also provided evidence that he did not identify himself as a mathematical literacy educator as there was a distinct absence of anything pertaining to mathematical literacy on his walls. The mathematics learning outcomes were neatly and effectively mounted on his pin-board walls but those for mathematical literacy were absent. Neither Michael nor Norman wanted to be known as mathematical literacy educators. They were emphatic in proclaiming that they taught Higher Grade Mathematics and that Mathematical Literacy was only an addition on their timetables.

Norman expressed that if the school continued to give him mathematical literacy classes to teach that he would leave; "if they think I am going to be the mathematical literacy teacher, they best start looking for my replacement". Having expressed their dissatisfaction with having to teach mathematical literacy it was interesting as to why neither educator inquired from their head of department or principal as to why the decision had been taken. One almost got the sense that they did not want to ask in case their suspicions as being the least suitable to teach mathematics would be validated, whereas if it went unknown they could continue to justify this with reasons that made them more comfortable. Such reasons for Michael included politics and race, for Norman a past history of complaints that were embedded in xenophobia.

Somehow the perceived status of the curriculum in the larger community and the status of educators delivering this curriculum was seen to be synonymous not in how they viewed themselves but in how they believed learners, parents and peers viewed them. This is in keeping with the literature that includes the reinforcement of images of teachers in the face of public scrutiny (Weber & Mitchell, 1995; Allen, 2005). This was further intensified by the fact that in neither of these schools did the Head of the Mathematics Department teach mathematical literacy. Having been told to teach mathematical literacy and not been asked also seriously contributed to the threat that Michael and Norman were feeling against their 'status-identity' as mathematics educators.

This threat to the status of teacher identity is significant not only because it is a scarcely researched area but also may be unique to mathematics educators particularly in developing countries such as South Africa. The reasons include not only the inherent status of mathematics educators in terms of implied intelligence but also the monetary value that the education department attaches to incremental increases of their employees, which favor mathematics educators and as such further validates the status of being a mathematics educator in South Africa. Monetary value attached to mathematics educators,' boxes' this group as an educational resource of higher value than most of the other learning areas.

This 'monetary value' was not expressed by either of the two educators in this research but goes to show the status with which such educators are regarded. Couple to this the scarcity of qualified mathematics teachers and it becomes clear why Michael and Norman felt this threat to their status and as such identity. For both these educators the feeling was so intense that they believed that the mathematical literacy label stigmatized them in a way that was not fair, as they did not deserve to be the ones chosen to wear this label.

This perception of not been fair also further led to internal competition and negative feelings towards the other departmental members and their heads of department that were not teaching mathematical literacy. Pfeffer & Sutton (2000:200) have found that such internal competition can manifest itself as a 'barrier to using knowledge':

> When internal competition turns friends into enemies. Little attention is paid to the power expectations so people are labeled as losers or as part of a bad unit and feel a lack of self-worth and resentment towards the firm.

Such signs were clearly present in both Michael's and Norman's working milieu. The emotional implications of this and the assumed stigma are profound, for if Michael and Norman are embarrassed to identify themselves as mathematical literacy educators and are feeling that their departmental heads and principals recognize little self worth in them in terms of being identified as mathematical literacy teachers, than the required discourse, reflection and change in their instructional practice may never be attained, as to pursue it would imply an acceptance of a label that neither educator wants to wear.

Emotionally the impact of having to teach mathematical literacy given that the teacher is a qualified mathematics educator is an area that requires further exploration. It can be reasoned that Michael and Norman felt threatened because they wondered if the community would continue to respect their apparent status, which they believed they held as a product of teaching mathematics. If this new curriculum had been understood in terms of its broader purpose not only by Michael and Norman but also by all the major stakeholders, this threat to identity may not have been as prominent as it was.

A deep change as to the value it holds to be entrusted with such a transformative curriculum would be required to ease this tension. It cannot be expected for parents and learners to re-define this when educators like Michael and Norman use labels such as "lesser maths", "I am not sure if it is credible in quality", "it is not real maths", "it is the beginning of maths", "it is a maths only better than nothing", "it is the maths of oranges and bananas", and "it is a subject for the doffies", to express their views on how they understand and respond to the value of this curriculum.

The reality is that deep change is even more difficult to attain on an emotional level .A recommendation would be that in the same way as mathematics educators are fiscally been valued so should mathematical literacy educators be. To address this impecunious view of what it currently means to teach mathematical literacy for Norman and Michael incentives and rewards could be considered as a staring point. To understand and appreciate that this curriculum provides for opportunities in terms of empowering learners to become 'numerically self-managing persons, 'contributing workers' and 'participating citizens in a democracy' is deep and difficult as it presents itself as an abstract ideal. However to attach some form of reward to the enabling of this ideal provides an opportunity to addressing the value that such a curriculum may potentially enable especially in a developing country whose workforce in itself is conflicted on the value of what they are teaching.

Odden & Kelley (2002) argue that school-based rewards are a means of providing motivation by introducing clear goals to the whole school which in turn facilitate student achievement. Such goals are necessary at FET High School and East Rand High School as they establish for all at these schools a reason why mathematical literacy is important and not that it was introduced simply because it had to be as a mandate by top-down prescriptions.

Another alternative is to re-consider who should be teaching mathematical literacy. In his discussion of appropriate roles in organizations, Collins (2001) talks about getting the right people into the right seats on the bus. Perhaps the right people for mathematical literacy are not the qualified and experienced mathematics educators who have previously taught higher-grade mathematics but educators that may not need to undergo a change in 'status-identity'. Ross (2004:592) writes:

> Many reforms contend that change in teachers' beliefs, habits, and attitudes toward mathematics will improve mathematics education. However, identity in relation to mathematics is constructed over long periods of time, through many experiences. To change an individual's system of knowledge (which amounts to a change in identity) is an intense and personal endeavor (*emphasis added*).

Such change in identity requires fundamental and deep changes, changes that Michael and Norman have indicated they do not want to make for such changes would not only threaten their identity but what they perceive as diminish the status of their identity as mathematics educators. For such change to occur then, the broader mathematical community needs to change their perception of mathematical literacy, for as Allen (2005:5) writes:

> Identities are continually recreated, unplanned, and automatic. The social face is on loan from society, for it is through society's recognition that one's identity is reinforced. It is society that determines what we do and who we are, the role that we play and the masks we wear. Identity is construed, maintained, and transformed through social interaction. The social structures in which we live provide the background of experience against which all of life is lived.

Apart from the pedagogical knowledge and threat to status of teacher identity several other themes emerged with regards to the role of teacher understanding of curriculum and its subsequent enaction. These themes are identified and discussed below.

8.5 Instructional Material

Both educators in this study were found to use the textbook as the predominant form of reference in their instructional practice. The choice of textbook was not predetermined but as a result of sample copies send to the schools by various publishers. Although both the textbook that Norman and Michael were using was significantly different to mathematics textbooks of the past the classroom observations revealed that both these educators used the parts of these textbooks that explained the use of mathematics formulas and rules. They made conscious decisions to strip questions and topics from the contexts in which they were embedded and predominantly delivered the algorithmic content to the learners.

Although the curriculum recommendations made it explicit that the instructional pedagogy should deliver the learning outcomes through the use and exploration of relevant contexts neither educator delivered the curriculum in this way. And when Norman did dress up the content with context this was done at such a superficial level that at times it simply included the use of pictures. For Michael, context was something he knew he had to deliver but would only do so when he felt that his learners had grasped the basic mathematical concepts. This pedagogical approach of both Michael and Norman was to a significant degree based on their beliefs and understanding that mathematical algorithms should dominate mathematics instruction, including that of mathematical literacy.

In their assessment practice that was distinctly separate from their actual teaching, Norman and Michael further used textbooks to set their assessment tasks. These summative assessment exercises were slightly more aligned to the curriculum intentions as they were mostly taken 'word for word' from textbooks that the learners did not possess. The deeper engagement of context that materialized here was not indicative of their understanding of the curriculum document but rather that of the textbook authors. As such to interpret that the assessment somehow reflected an appreciation of what was in point of fact required by the curriculum would be a misinterpretation for it only reflected that the educators chose to utilize material that was readily available rather than to set their own assessment tasks. If their comprehension of the curriculum is to change, Michael and Norman must "become more assessment literate" as this provides access to opportunities for better understanding and instruction (Hargreaves, A. & Fullan, M, 1998).

Davis and Krajcik (2005) in a synopsis of literature on the use of textbooks describe how teachers use such reference materials:

> Teachers' use of and learning from text-based curriculum materials depend not only on the characteristics of the curriculum material but also on the type of teaching activity in which the teacher is engaged, the teacher's persistence or lack of persistence in reading materials over time, what the teacher chooses to read or ignore, the teacher's own knowledge and beliefs (e.g., about content, learners, learning, teaching, and curriculum materials), how those beliefs are aligned with the goals of the curriculum, and the teacher's disposition toward reflective practice ...These factors interact in a complex and dynamic relationship as teachers interpret the curriculum materials and shape the enacted curriculum...

Norman and Michael's continual use of the textbook and what they chose to ignore and what to teach was mostly based on pedagogical content knowledge that was sparingly connected to the Mathematical Literacy curriculum. This knowledge that is required to teach the content (Shulman, 1986) was lacking in both these educator's instructional practice. And if as Davis and Krajcik (2005) argue that promoting teacher learning is even more complex than promoting student learning the task to 're-educate' Michael and Norman in terms of their understanding and beliefs on what the nature of mathematical literacy entails takes on a monumental requirement. For not only do these educators require training in what the curriculum necessitates in terms of pedagogy but also a change in what they believe the teaching and learning of mathematics to be. This change in the core assumptions and beliefs with regard to both teaching and learning requires as Coburn (1993:4) explains a deep change:

> By 'deep change' I mean change that goes beyond the surface structures or procedures (such as changes in materials, classroom organisations, or the addition of specific activities) to alter teacher's beliefs, norms of social interaction and pedagogical principles as enacted in the curriculum.

The research findings concur with this viewpoint, as the textbooks that Michael and Norman were using were notably dissimilar to those of the past and yet neither educator had a deep awareness of this or how to best utilize these. A change would necessitate instruction that deals not only with the required pedagogical process but also instruction on understanding the nature of mathematical literacy.

This nature is conspicuously in deviance to the nature of past mathematics curricula and as such demands a reflective understanding of the disparity between numeracy and mathematical literacy. The way that Norman and Michael delivered the curriculum was more in line with what could be anticipated in the conveyance of a curriculum for numeracy. Their focus and emphasis of mathematical algorithms and formulae evidences this. To acquire the knowledge on the disparity in concepts is difficult, as it requires 'deep learning' not of content but of a concept that is patently new in the South African secondary school mathematics curriculum.

8.6 Educational Backgrounds

Michael was far better qualified in mathematics than Norman. He held a BSc degree and had done Mathematics III. Norman was less qualified in that he had done a teachers primary school diploma, which he had then changed to a high school diploma in one year. According to Shulman (1985), to be a teacher calls for far-reaching and highly organized bodies of knowledge. Elbaz (1983) holds the same view when he identifies teachers' knowledge as the single factor which appears to have the furthermost influence to carry forward teacher understanding of the teachers' role. Such bodies of knowledge, the evidence of this study showed, were not simply a consequence of teacher qualification as the 'higher' qualification of Michael did not significantly enhance his understanding of the Mathematical Literacy curriculum. This is an important revelation of this study for before the implementation of mathematical literacy it was widely debated as to who was going to teach this curriculum. From these two educators it seems that even though a qualification in mathematics is required the level of that qualification is not considerable in better enactment of the curriculum in the actual classroom.

It could be argued that the qualification in a way is a hindrance in that the two qualified teachers did not believe that they should be teaching mathematical literacy. It would however be inattentive to express that this implies that this curriculum can be taught by anybody. Michael felt that schools committed 'treason' when they used educators to teach mathematical literacy that were not well qualified, but did contradict him when he expressed that this should not include himself. Norman also held that the teaching of mathematical literacy required mathematically qualified educators but once more did not include him.

Literature is replete with evidence on how the low levels of mathematical subject knowledge impact on learners' outcomes (Darling- Hammond, 1997; Weiss, 1994). What this study furthers is that the converse is not always implied. That is, if teachers subject knowledge is of an acceptable level it does not necessarily hold that such teachers can deliver mathematical literacy as intended. This is of substance, for as already mentioned, before the actual implementation of this new curriculum, debate was rife as to who should be teaching mathematical literacy. The contention that it does not of necessity need to be mathematics educators may prove to be significant if this curriculum is to be taught as proposed. It would be perhaps easier to educate teachers in another discipline than to're-teach' educators in the discipline of mathematics. The former requires training, the later requires abandonment of old beliefs and practices as it requires changing a culture, which as Sergiovanni (1998:577) observes:

> [Changing a culture] requires that people, both individually and collectively move from something familiar and important into an empty space. And then once they are in this empty space, to build new set of norms, a new cultural order to fill it up. Deep change, in other words, requires the reconstructing of existing individual and collective mindscapes of practice.

As such, the former presents itself, simply put, as a lesser 'painful' alternative. Furthermore it also does not compete with draining the few mathematics educators that are well qualified and experienced from the Mathematics classrooms. The shortage of which is not uniquely South African but widespread even in developed countries[33]. In developing countries this lack of well-qualified teachers is even greater generating a dire domino effect on learner outcomes.

8.7 Learner Expectations

Mathematical Literacy as a mandatory alternative to mathematics presupposes that all learners can and should do some form of mathematics. As an equity reform it further allows all learners access to mathematics. However the broader philosophy of this curriculum is more about accessing mathematics as this is how the curriculum envisages the attainment of the three main purposes, namely to provide and develop skills in learners that are required by 'numerically self-managing persons, contributing workers and democratic participants'.

This standard was however not been realized in either Norman nor Michael's classroom as they believed that the majority of learners doing Mathematical Literacy did not have the mathematical pre-knowledge required by the Grade 10 Mathematical Literacy curriculum. In Michael's classroom the majority of learners taking the subject either failed mathematics in Grade Nine or where placed in the class as new students with a history of very low attainment in mathematics. For Norman the scenario was very much alike. The learners in his Mathematical Literacy class either failed Grade Nine Mathematics on the year aggregate or failed the end of year examination. As such both these educators were influenced not only in the level of knowledge and skills they chose to deliver to these learners but also in their expectations of learner outcomes.

[33] In England: "the shortage of suitable teachers continues to be perceived as a major problem in terms of delivering the secondary mathematics curriculum" p4-2002/3 *Annual Report on Curriculum and Assessment (Mathematics)* published in March 2003 the QCA.

Norman referred to his learners as 'doffies' and the evidence from the classroom observations indicated that this perception of his learners' ability undoubtedly impacted on the implementation of the new curriculum. His lessons did not support higher order skills and his continuous focus on basic mathematics concepts precluded learner engagement in new ways of learning and thinking. He also admitted to often having to re-teach sections of work as he found that the learners were not coping with the material. In his opinion the reading was causing much of the problem, however the observed lessons revealed that the actual mathematical content was what the learners were struggling with.

The responses from the learners themselves also further evidenced this as they indicated that they struggled with mathematics concepts and formula. What is more is that Norman referred to the mathematics in the Mathematical Literacy curriculum as the "maths of oranges and bananas". An intimation of how he perceived the curriculum that he was teaching. This value judgment further enforced in Norman a perception of how weak his learners actually were, for if they were unable to muddle through a curriculum that he considered very easy and trivial it stigmatized his learners ability, when not acquiring the outcomes, even further.

What becomes noteworthy is that his perceptions of his learner abilities negatively affected the implementation of this new curriculum. Having claimed that his expectations of his mathematical literacy learners were high but realistic he exhibited behavior that was noticeably indicative of having very low expectations of his learners. His lack of expectation in terms of homework done and eliciting learners' response was evident throughout the six-week observation period.

In terms of equity reform and’mathematics for all' his acuity as to who could and could not do mathematics was clearly expressed in his following retort: "not all pupils can do mathematics, but at least mathematical literacy is something". What exactly this 'something' was was never explained any further, but the impression given was that it was basic numeracy. His beliefs on what the learners in his classroom could achieve were clearly embedded in his learners' previous history of mathematics achievement.

Similarly, Michael had no higher expectations of the learners in his mathematical literacy class. His lessons and assessment practice did not extend them beyond what he also referred to as the 'basics'. This emphasis on basic numerical and calculator skills hindered him from affording his learners material and knowledge that was either empowering or enriching in terms of experiencing mathematics in contexts relevant to everyday lives.

His emphasis on building the basics and focusing on questions, which he believed to be of manageable ability, did not take into account individual needs or wants. His awareness that some of the learners in his class 'feared mathematics' also did not prevent him from making comments about his learner's abilities and he further reinforced this, even though it seems to have been on a subconscious level, in his instructional practice. His altercation with one of his learners when that learner indicated that he had found the homework difficult can be assumed to have caused embarrassment and humiliation to his learner when he uttered the following:

> *It is not difficult; you just cannot do it. If your friend can also not do it then maybe he should also be in this class. Hands up, if you also found it difficult.*
>
> *You see, maybe you and you friend should be in a special class of your own.*

This substantiates his perception of how he viewed not only that learner's ability but also any learner doing the subject of Mathematical Literacy. The implication being that Michael held that learners taking core Mathematics as a subject were more intelligent and able than those doing Mathematical Literacy.

Both Norman and Michael’s views were such that seemed to indicate a predetermined expectation of their learners that predestined them from ever achieving the high knowledge and skills that the curriculum purported to afford. These low expectations of learner outcomes for Norman and Michael were such, as both these educators did not intrinsically believe that the mathematical literacy curriculum was an opportunity to alter learners' outcomes with regards to any 'real' form of mathematics. They were both clearly under the impression that the low levels of numeracy with which their learners came into Grade Ten implied that they would have low levels of mathematical literacy. Although it can not be disputed that these numeracy levels clearly played a role in the learners ability to comprehend lesson content it can be argued that they were obstacles of immense extent for the reason that the lessons' prominence was one of hierarchical dominance of content. As such the challenge becomes the educators in creating a learning environment that engages their learners' past mathematical histories while at the same time developing and furthering their mathematical literacy skills. Donovan, Bransford and Pellegrino (1999) explain this as follows:

> Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp new concepts and information taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classrooms.

The deep change required for understanding new concepts includes lessons that are not of traditional instruction as well as a change in their beliefs and understanding of the difference between the concepts of mathematics, numeracy and mathematical literacy. These changes are so edifying that it is incomprehensive to assume that reading a curriculum policy and attending a single teacher-training workshop by these two teachers can achieve this type of change. Such meaningful and deep change requires extensive strategies that are continuous to both develop and sustain this need. This required delivery is possible but only once all stakeholders believe that it is worth investing in. The central tenet underlying this charge is a clear vision of what the value of mathematical literacy is by both the workplace and the Higher Education Sector, and not only the curriculum which states (DoE, 2003):

> It sets up high expectations of what all South African learners can achieve. Social justice requires the empowerment of those sections of the population previously disempowered by the lack of knowledge and skills. The National Curriculum Statement specifies the minimum standards of knowledge and skills to be achieved at each grade and sets high, achievable standards in all subjects (3).

> An education system does not exist to simply serve a market, important as that may be for economic growth and material prosperity. Its primary purpose must be to enrich the individual and, by extension, the broader society (5).

Why neither educator believed that this was possible allows for the interpretation to be made that these educators had not undergone any significant change let alone a deep change as to what the nature of this reform calls for, in terms of challenging their assumptions on who can and can not be taught mathematical literacy. Until educators believe that this curriculum allows for and makes provision in terms of the required pedagogy and content for high levels of knowledge and skills the implementation of this curriculum will not take place 'in the spirit' and with the moral purpose with which it was intended.

Michael Fullan (2006:19) in his report on *Effective District Wide Strategies to Raise Student Achievement in Literacy and Numeracy* states:

> The districts held an educational vision that extended beyond narrow attainment measures to a belief in the moral purpose of education, which included an expectation-and indeed assertion-that all students can learn and that all teachers can teach students to learn given sufficient support and time. The districts developed and promoted high expectations and positive attitudes for student learning and achievement.

This 'expectation-and indeed assertion-that all students can learn' was clearly not visible in either of their practices. However they both held that they were able to teach mathematical literacy and never questioned whether what they were doing could in any way be done differently. To change such behavior and perception requires not incremental change but a deep change, as it is completely discontinuous from the past. Quinn (1996:3) observes:

> [Deep change] requires new ways of thinking and behaving. It is change that is major in scope, discontinuous with the past and generally irreversible. The deep change effort distorts existing patterns of action and involves taking risks. Deep change means surrendering control.

This view of deep change holds for the dismantling of the status quo. It requires the deconstruction of views and beliefs and an abandonment of the past and a start from the very beginning. In so doing, it requires discipline, courage and motivation, which is at the core of changing ourselves (*ibid*). In so doing it also necessitates recognition that this is required. Recognition that neither Michael nor Norman displayed in their instructional practice.

Michael stated that all learners "cannot do maths" but that "everyone could do mathematical literacy if taught properly". Having later on admitted that his learners were not coping with mathematical literacy the inference would be that he was not teaching them 'properly'. Yet, Michael did not see his learner outcomes as a reflection of his own instructional ability but rather as a result of his learners' past history with mathematics.

And, if it was not for the externally set Grade Twelve examination that presented itself as an ominous cloud for both Michael and Norman their instructional practice would support learner outcomes to an even lesser extent, as it was this pending examination that forced them to aspire to teach the curriculum content in its entirety.

Michael like Norman did however believe that mathematical literacy could provide for high levels of skills and knowledge, but not to the learners that were taking the subject. The two teachers did not hold themselves accountable for their learners' results.

There are deep consequences for this lack of accountability for the fate of this reform curriculum in that if Michael and Norman do not change their perceptions on who can and cannot do mathematical literacy and change their views on learner attainment and who is accountable for this, this new curriculum will not be effectively implemented in their classrooms. The purpose of introducing this curriculum then, which includes, empowering the workforce with skills that are demanded by the 'Information Age' and the serving of the "market place" (DoE, 2003:5) may never emerge.

Many arguments have been made that there is no empirical evidence that curriculum reform improves the economy of a country in either developed or developing countries (Psacharopoulos, 1986; Camoy & Samoff, 1990), but such arguments do not consider that many countries where the levels of numeracy and mathematical literacy are considerably low if not unacceptably so occur in countries with low economies. As such it would be fair to state that a reform seeking to empower the workforce of such developing countries if implemented as intended, given the limitation that the curriculum design and content is of value, may go some way in altering the micro-level economy, even on a personal level, for such countries, South Africa included.

What all this points to, is staff development that mandates teacher accountability in terms of pursuing a deep change of what they believe students can and cannot learn. In *Effective District Wide Strategies to Raise Student Achievement in Literacy and Numeracy* Fullan (2006: 18) observed the following," A lack of focus on student achievement was widely understood as being unacceptable, and there was low tolerance for excuses about poor performance". Such levels in Michaels and Normans classrooms were not only acceptable in terms of justifying learner outcomes but were also used as excuses for not engaging these learners with the required level of knowledge and skills that the curriculum afforded. As such, strong strategies are necessitated that address how teachers should cultivate already held beliefs and understanding to suit those that are new and requisite for the learners of the Mathematical Literacy curriculum.

Teacher training programs must address the purpose of change by providing empirical evidence not only of the failure of the 'old' but also of 'successes' of similar curricula as that of the 'new'. Intervention strategies that support struggling mathematics learners are also further required and educators need to be trained in terms of 'best practice' teaching and learning strategies, if the attempt is to reach and affect the majority of South African learners. At the same time this staff development must account for and provide solutions for the complexities associated with teaching in contexts that are impoverished in terms of resources and human capacity.

8.8 Resources

The resources available to Norman in terms of materials to teach with were less than those of Michael's in that Michael had more computer technology available to him than Norman did. Norman had three textbooks and a scientific calculator. Michael had similar resources but also access and skills to use the computer laboratory, which he chose not to do. For Michael, it was pointless to integrate his instructional practice with computer technology as he felt that if his learners were struggling with the use of the scientific calculator how would they be able to cope with other technology. This perception of Michael's not only limited the learning opportunities of his learners but also the curriculum intentions as designed. Norman spoke of needing access to the Internet in order to acquire material that he could use in his practice and saw this as a major and restricting obstacle to his teaching of mathematical literacy. Michael did have free and readily available access to the Internet but other than the exemplar paper that he had downloaded from the Thutong website he made no other use of the Internet in terms of acquiring resources.

The Teacher Guide for Mathematical Literacy lists the resources needed to teach this curriculum to include the following: textbook(s), advertisements from the media that refer to percentage and interest rates, articles and advertisements from the media that are supported by graphs and tables, sales brochures offering different payment methods, nutritional panels from food packages, municipal utility account statements, municipal tariff tables, banking brochures, recipe books, tournament logs and results,timtables for trains and other transport systems, national and regional maps, basic calculators, rulers and measuring tapes, measuring jugs,scales,pairs of scissors and compasses, stopwatches and clocks, graph paper,protractors,glue and string, elastic bands and paper clips (DoE:2006).This comprehensive list includes many resources that could readily be available to both Norman and Michael despite the contexts in which they found themselves working in. Yet the only two that dominated their practice was primarily the textbook and secondary the scientific calculator. It can be inferred from their behavior in the lessons and from their replies to the questions in the interviews and questionnaires that this use was not limited because they did not have access to most of these other resources but because they did not value their use as a requirement in the teaching of the new curriculum.

Furthermore, four official documents were available for Mathematical Literacy at the time of the study, namely the Mathematical Literacy Subject Statement (DoE, 2003), the Subject Assessment Guidelines: Mathematical Literacy (DoE, 2005), the Learning Programme Guidelines: Mathematical Literacy (DoE, 2005), and the Teacher Guide: Mathematical Literacy (DoE, 2006). Of these documents Norman was only in possession of the Subject Statement and Michael of the Assessment Guidelines and Subject Statement, all of which had been handed to these educators by their respective heads of department. The use of these documents by both these educators was limited to acquiring the content that had to be taught in terms of drawing up weekly schedules and year plans. Neither educator engaged with the official documents in any other way. Even the understanding of Chapter Three in the Subject Statement that deals with the learning outcomes and assessment standards required was limited in acquiring the broader area of what was to be taught.

I have argued that a strong theory of action, in terms of teacher development strategies, needs to accompany this new curriculum. However due to the teacher's thin and disconnected interaction with official documentation, if this was to be embedded in such documents, it can be assumed that it either would go unread, or if it were read it would be interpreted on a superficial and personal level, in the same way as the purpose and possibilities were by the two teachers.

The workshop that both educators had attended had also not provided training and learning that had significantly altered the instructional practice for either Michael or Norman. Having analyzed the material handed out at the workshops it was evident that these programs had provided for some level of explaining teaching mathematics in context and a relative amount of scaffolding that was required for the necessary change in instructional practice. Why had Michael and Norman not incorporated what was delivered in these workshops can be based on three revelations. Firstly the workshop did not elucidate the purpose of the reform nor did it make mention of the crisis in mathematical literacy in South Africa and as such did not make it explicit as to why Mathematical Literacy, the subject, had been introduced. Secondly, there was no distinction made between numeracy and mathematical literacy and as such the focus was on numbers with the use of context acting as a 'dress up' for the mathematical content. Thirdly, its early delivery was too soon in the implementation process of mathematical literacy and the educators did not have enough experience to be able to reflectively engage with what was been taught.

Teacher training not only needs to provide for deep learning but also needs to provide this at a time when educators are most receptive. What is more is that those responsible for such training need to have ownership of the curriculum and a collective commitment towards what they intend to explicate. To foster a collective commitment implies that both those responsible for training and those responsible for learning believe in the possibilities and value of the new curriculum and hence the reform, both of which were profoundly found to be lacking at the time of the study.

One major contributing factor was that the higher education sector was uncertain as to how to value this new curriculum and most tertiary institutions were hesitating to provide information as to which doors Mathematical Literacy opened or closed. The only certainty was that learners taking Mathematical Literacy as a subject and attained forty percent and above would obtain a university entrance. This was fervently pursued by most of the learners in both Michaels and Norman's classroom.

One of the learners in Norman's class stated that he was doing Mathematical Literacy for by doing the section on Mathematical Finance he would be able to study further as a Chartered Accountant. Neither the learner nor Norman was aware that this door, Mathematical Literacy did close. Such confusion results when all stakeholders have not collectively bought into the value and possibilities of a new reform. It begs the question then as to how the government can allow for the introduction of a new reform before all the groundwork necessary for understanding the reforms value have been established.

In addition, because deep learning is a necessity for deep change it takes time and thus cannot be acquired by simply reading official documentation. So to provide these educators with all the documents they did not have in their possession will not be of consequence unless teachers are provided with opportunities to reflect upon and discuss the curriculum as it unfolds in their classrooms. Such opportunities can only be afforded by programs that are continuous and not 'once off' if change is to be sustained particularly at the onset of a new reform. Once momentum is gained and the instructional practice of educators has significantly changed, then and only then can it perhaps be relied upon that these educators will similarly train those entering the mathematical literacy profession.

The learning resources for the two educators of the study also differed in that Norman's learners did not have textbooks and Michaels did. It was observed however that the possession of these textbooks or lack thereof did not markedly contribute to a different lesson delivery in terms of work covered or homework set. This is not to say that the conditions in Norman's classroom were not more difficult but that having textbooks did not markedly impact on the implementation pathway of the curriculum in Michael's classroom. The fact that the learners in Norman's classroom did not have textbooks did constrain Norman's lessons in that his learners spend a lot of time copying exercises and questions from the textbook rather than using the time to engage with their teacher in the requirements of the days lesson. However, despite this and the other shortage of resources that the learners had, this study revealed no evidence that would support that if the learners and educators had more resources their instructional practice would be any different.

What is worthy of mention is that such evidence does go towards showing that in developing countries the delivery of textbooks to the classroom will not magically resolve the problems of educating economically disadvantaged learners. This is not to say that textbooks are not necessary with respect to 'opportunity-to-learn' Tate (2004). It only suggests that even of graver necessity is a teacher workforce that can use these textbooks and other obtainable resources in a manner that will most benefit the learners.

This requires 'deep learning' which is not only about working smarter and harder but also accruing resources that enable one to go deeper and further (Fullan, 2005b). Resources that, as mentioned, both Michael and Norman could acquire a lot of if they knew not only to look for them, as they both claimed that they should find articles in the newspaper that were topical but had not done to date, but rather to look for them because they believed that it would benefit both the teaching and learning of mathematical literacy. Such a mind shift would require collaboration with peers and stakeholders and some semblance of a reflective practice, both of which were also found to be scarcely pursued by both the teachers in this study.

8.9 Collaboration & Reflection

In Norman's school there were four mathematics educators of which he and one other were given the duty to teach the Mathematical Literacy curriculum. His head of department was not one of them, and the five departmental meetings observed which were held once a week did not provide any evidence of discourse or reflection on how these two educators were implementing this new curriculum. The focus of the meetings was mostly planning and other than discussion on what section was to be taught next and for how long, the discussions at these meetings did in no way provide for any in-service training.

Norman claimed that discussion was not required as he new what he had to teach. This was loosely based on his assumption that because he believed that he had a mastery of the mathematical content requisite by the curriculum he was implementing this new curriculum successfully. He explicitly stated this when he said that at looking at the exemplar paper that a colleague of his from another school had given him, the work that he had covered to date, he had done so correctly. If the learners were unable to do this work it was not a reflection of his teaching but rather of his learners' ability.

Other than the planning mentioned there was also no deliberation between Norman and his colleague at FET High School that was also teaching the subject on what mathematical literacy entailed, or how it was unfolding in his classroom. The principal of the school was additionally also uninvolved in what was happening in the delivery of this new curriculum. His only connection with Norman was that of assisting with disciplinary matters if the learners were found to either misbehave or show disrespect.

At the cluster meetings that Norman attended, a similar pattern was described by Norman. He mentioned that discussions did not include the mathematical literacy curriculum and were mostly focused on sharing ideas and information with regards to the core Mathematics curriculum. Once again, the main reason why Norman did not attempt to discuss mathematical literacy was because he believed that what he was doing was sufficient and correct. His beliefs were in turn based on the understanding he had of the mathematical content that he had to deliver.

For Michael collaboration and reflection was also not part of his mathematical literacy instructional practice. At East Rand High School there were five mathematics educators and Michael was the only one teaching mathematical literacy. His head of department also held weekly meetings that also failed to provide a forum of discussion on how the implementation of mathematical literacy was taking place in his classroom. He solely barred the responsibility of this new curriculum at his school, not only because he was the only teacher teaching mathematical literacy but also because he chose not to engage with discussion on this new curriculum. His behavior can also be explained with regards to his understanding of the mathematical content that he taught, which he explicitly believed he had a mastery of.

At the one cluster meeting attended by Michael, during the observation period of this study, there was also no dialogue on the mathematical literacy curriculum in terms of content, pedagogy or purpose, and the only mention of the subject was that they should not worry too much about how the learners were doing as all the educators present at the meeting were clearly under the impression that no learner would fail Mathematical

Literacy in Grade Twelve, which was two and a half years away. This rumor was rife and the educators were under the impression that this was so because the Department of Education had got the level of the curriculum wrong. Michael agreed that the standard of the curriculum was too difficult for the learner's taking the subject and expressed that the Education Department may have realized this, and would not fail the learners taking Mathematical Literacy for several years while they sorted this problem out. For Michael, this rumor did not seem to consciously influence his practice in any way as he claimed that he would have to see it in writing to believe it.

For Norman, who had also heard this rumor, the impact was significantly different, as it seemed to put him at ease with the way his learners were achieving. He claimed that this was also true of the other educators in his cluster that had told each other not to worry about how their learners were experiencing the curriculum, as they would all pass this in their Grade Twelve year.

Having inquired into this rumor I found that departmental officials even though hesitant to admit that this rumor was true were as hesitant to deny it. They referred me to policy documents that indicated the required pass aggregate for Mathematical Literacy. One mathematical stakeholder that is highly regarded in educational circles and consults for the Minister of Education on mathematical matters admitted that this was a discussion that was busy taking place.

It is uncertain that in the absence of this rumor more discussion and reflection would be taking place in Norman and Michael's cluster. But it is certain that this perception prevented Norman, at least, from worrying about his students' struggle with the mathematical literacy curriculum.

What is more is that in less than nine months both Michael and Norman believed that they had successfully implemented the Mathematical Literacy curriculum. For both of them their main reference point was the exemplar paper that they had in their possession. This seemed to vindicate for them what they had been doing, a finding that was confusing as the exemplar paper was by no means similar to either of their instructional practices. And yet, Michael and Norman were confident in that they were teaching mathematical literacy 'correctly'. The use of 'correctly' is important for not only was it used by both educators to describe what they were doing but also to emphasize that for these two educators it was either right or wrong.

This viewpoint hindered reflection on their instructional practice and in the absence of a collaborative network indicated that this concentration of detachment of understanding can only but remain at this surface level for as Fullan & Hargreaves (1991) observe, there is a ceiling effect to how much we can learn if we keep to ourselves. Dialogue arbitrates collective sense. By critically exploring and examining other educators' instruction and reasoning and partaking in the solution findings of incongruity, educators learn to monitor and change their thinking.

Michael and Norman's belief that what they already knew more than sufficed in delivering the curriculum also further prevented them from holding themselves accountable for the learner outcomes. As such any change that may still be needed in terms of holding learning as a function of teaching, will not take place unless it is supported, understood and driven by professional learning communities.

Professional Learning Communities allow for teachers to develop as a result of continuous interaction, shared understanding and commitment to achieve high level outcomes for all students Newmann (1998). These should also include those in a position of leadership. Fullan (2005a: 30) explains for the difference that this makes:

> What does make a difference is recapturing the process of developing professional learning communities in the school. Recapturing involves going from a situation of limited attention to assessment and pedagogy to a situation in which teachers and others routinely focus on these matters and make associated improvements. Structures can block or facilitate this process, but the development of a professional community must become the key driver of improvement. When this happens, deeper changes in both culture and structure can be accomplished.

Leadership is important as it allows for sanctions and rewards and thus accountability. Hay Management Consultants (2000) compared two hundred highly effectual principals, with two hundred senior executives in business. The five domains of leadership identified were: teamwork and developing others; drive and confidence; vision and accountability; influencing tactics and politics; and conceptual and analytical thinking styles (Fullan, 2002). Ferrini-Mundy & Johnson (1997) further claim that available evidence suggests that significant change in how teachers teach mathematics can occur with strong administrative support and an intense and sustained program of professional development focused on curriculum, mathematics content and pedagogical issues. Fullan, Campbell & Glaze (2006) support this assertion with their findings that show that within schools, principals with deep knowledge and understanding of successful literacy and numeracy practices were important for ensuring such approaches were applied in classrooms. The leadership at Michael's and Norman's schools did not exhibit any of these domains with significant depth as regarded the introduction of the Mathematical Literacy curriculum, which in term impacted on how these teachers functioned-as solitary change agents.

As it is unlikely that schools will appoint mathematical literacy educators as leaders for the time being, there is a need to develop not only the educators teaching mathematical literacy but their heads of departments and principals. This ideal is recommended to take place simultaneously with implementation Fullan (2003), however as it has not yet been realized a concerted effort is required to both pursue and introduce it. This pronouncement is sizeable for there was no indication during the time of the study that any of the workshops were designed to include anyone else other than the educators who had been assigned the task of teaching mathematical literacy for the very first time. The selection or omission of which this study revealed led to conflict not only as a result of a lack of support but also of professional competitiveness that also significantly impacted on the evidenced feeling of a threat to the teachers 'status- identity'.

This study adds to this scholarly text, in that in South Africa and perhaps other developing countries with low levels of mathematical literacy, pedagogy and assessment may be important for mathematical literacy but they will not be effectively transacted upon unless the curriculum purpose in terms of transformation is spelt out and engaged with as an opportunity to establish a culture and ethos of higher learner expectations, not only by mathematical literacy teachers but also by those in positions of leadership.

Jointly these findings have implications for mathematical literacy reform, and are discussed below.

8.10 Implications for Mathematical Literacy Reform

The thin and disconnected understandings of the Mathematical Literacy curriculum of the two educators in the two case studies echoes an expansive literature (Hill *et al*, 2004;Sherin, 2002;Shulman & Grossman, 1988;Mwakapenda, 2002) that recognizes the complexity of bridging the gap between curriculum as intended and curriculum as implemented in the context of actual classrooms. Added to this, the introduction of this new curriculum implores a linear link between curriculum and practice as it provides an implicit theory of change without providing a theory of action. The transformation required in moving between and beyond teaching mathematics to mathematical literacy indicates by all accounts that a deep change is necessitated not only for educators delivering this curriculum but also for all stakeholders of the broader mathematics community. The evidence provided through an explorative design urges that action strategies must provide the implied change theory with support that enables the changes required.

Norman and Michael had a surface level understanding of the curriculum because in the absence of strong teacher development strategies they were not empowered with a deep engagement of the curriculum. Rather than internalizing and understanding the changes needed, they implemented the curriculum thinking that they had made the necessary changes when in effect these were far removed from the curriculum design.

Strategies required were evidenced in the following fields; personal transformation needed in terms of understanding the concept and nature of mathematical literacy as a subject, a consideration and reflection on the impact of beliefs on who can and can not do mathematics, requisite pedagogy of teaching mathematics in context, thought and planning as to who is to teach mathematical literacy, lack of leadership in terms of collaboration and reflective practice, valuing of the curriculum by all stakeholders, and valuing mathematical literacy educators as a deflective process to the threat of 'status-identity'.

The propositions that were positioned to accompany the research questions were further evidenced as follows:

Proposition One:

Michael and Norman did not have a deep understanding of the purpose and possibilities contained in the Mathematical Literacy curriculum. Their level of understanding was thin and disconnected to the curriculum intentions.

Underlying this finding was the lack of interaction with the curriculum document as a result of such interaction been viewed as an acknowledgement of not understanding a 'lesser subject'. A deeper engagement with the curriculum would have further exacerbated the threat to the 'status-identity' that these teachers were experiencing when being identified as mathematical literacy educators.

Proposition Two:

Michael and Norman implemented the Mathematical Literacy curriculum using beliefs, pedagogy, and understanding that were already entrenched in their mathematics practice. They proceeded to implement the curriculum in a way synonymous to numeracy or the old standard grade mathematics curriculum .The change of using context only dressed up the content and did not align itself with the required and stipulated pedagogy.

Underlying this finding was the prejudice shown in favour of mathematics formulae and algorithms as an acknowledgement of the superiority of numbers over context. This prejudice, further prevented threats to the 'status-identity' of these teachers as mathematics educators.

Proposition Three:

Both teachers of this study implemented Mathematical Literacy at their schools because they were told to do so. Neither educator had embraced the 'spirit' nor the purposes of the reform nor wanted to be regarded as the mathematical literacy teacher.

Underlying this finding was the little value that the curriculum held for both these teachers. Not as an explicit judgment of the curriculum content *per se*, but rather as a reflection of popular public opinion.

8.11 Concluding Remarks

Norman and Michael were unable to make the changes required because policy and planning did not provide sufficient strategies or support for these educators. Analyzing Norman's and Michael's understanding of the curriculum through the conceptual framework of deep change, this study extended the evidence base in developing countries on the difficulty of pursuing a transformative reform in mathematics in the absence of a strong theory of action by providing the following insights:

Firstly, a mathematics curriculum distinctly different from curricula of the past was diktat on educators without due consideration on how substantial the required change would be in terms of understanding the purpose and possibilities of this new curriculum. A purpose that in transforming mathematical literacy levels in South Africa presupposes some or other level of social justice. As such it obliges a collective moral purpose and a belief that all pupils can be taught to become mathematically literate. Such deep understanding was distinctly absent not only in the schools that made up the two case studies but also in the snap-shot survey that involved over fifty educators.

Secondly, there was an assumption that educators understood the concept of mathematical literacy that by its very own nature is distinctly dissimilar from that of mathematics or numeracy which can be considered as the only previously taught and learnt mathematics, by educators in South Africa. This assumption of being able to comprehend a new concept by simply reading a curriculum document fails to consider the broad literature that shows that if meaning is left up to the teacher to be acquired a 'great variability' in understanding will occur (Hill, 2001;Spillane & Zeuli, 1999,Drake, 2002).

Thirdly, there were no provisions made for strategies to empower educators to deal with and assist learners with a past history of low attainment in mathematics. Such strategies are imperative for as seen in Michael and Norman's classrooms, the learners doing mathematical literacy had a history of low mathematics success. Taking into account the impoverished mathematics educator workforce many of these learning difficulties they had acquired can be contributed to poor learning. To address these gaps learning policy has to make explicit what the required pre-knowledge of mathematical literacy learners should be and provide stratagems to educators and opportunities to learners to bridge the gap for knowledge required when beginning mathematical literacy in Grade Ten.

What is more is that a change in beliefs has to be pursued in the educator work force on who can and cannot do mathematical literacy. It is imperative that educators begin to hold themselves accountable for the learning of their students.

A fourth insight gleaned from this study was that there was an absence of collaboration and reflection on how mathematical literacy was been implemented. This was not only as a result of Michael and Norman believing that they already had implemented the curriculum successfully but also as a result of the absence of involvement and interest of the leadership structures directly above them. The head of departments and principals of these schools did not involve themselves with the implementation of this new curriculum and any discourse at the departmental meetings and cluster meetings tended to focus on planning and complaining about how difficult the learners were finding this curriculum, rather than exploring and discussing issues of pedagogy and best practice. Mathematical Literacy learning communities were distinctly absent.

Lastly, a surprising but major and overriding insight that emerged from this study was that this curriculum reform threatened teacher identity, not in terms of ability and 'intensification' of work, but in terms of a threat to status of teacher identity. The two mathematical literacy educators did not want to be identified as such as they felt that this diminished their value in terms of how they were perceived as educators by the broader community. This, significantly and negatively impacted in their engagement with any form of discourse that would illuminate and lessen the emerging problematic findings mentioned above.

8.12 Implications for Future Studies

This study explored and explained the implementation of mathematical literacy in its first year of introduction. The two educators responsible for this at two urban high schools in South Africa did not change deeply as was required by this reform. Having posed the caveat earlier on that perhaps it was too soon to expect deep change I challenge that this will not take place in these educators future as they both believed that this change posed a major threat to their mathematics teacher 'status- identity'.

As a result they did not reflect on their practice, and in the absence of informed and collaborative leadership in terms of head of departments, principals, professional learning communities, and also in the face of a lack of any future training of any of these stakeholders on the value of mathematical literacy, it can but only but be assumed that their instructional practice will remain largely unaltered in future. This line of reasoning points to the following suggestions for future studies:

- Research is required on the attributes of teachers more likely to embrace a mathematical literacy curriculum. Is it easier to train teachers that are not qualified in mathematics to understand the nature and pedagogy required by this new curriculum, or is it reasonable to assume that qualified mathematics educators and the larger community will gain a deep understanding of the value of this reform so that these educators do not perceive a threat to their the professional status identities? The question of interest in, or performance by, qualified or not mathematically qualified educators could be a topic of research.

- What intervention strategies are best suited for learners with a history of low mathematical attainment in continuing successfully with mathematical literacy?

- Does a deep understanding and appreciation of the purpose and 'spirit' of a curriculum enable a deeper understanding and delivery of that curriculum?

- What strategies are best suited to train teachers into using pedagogical content knowledge that is best suited to teach mathematics in context?

- What would motivate qualified educators to want to teach mathematical literacy in the first place?

- A need exists to document the impact that mathematical literacy has on the self worth of learners taking mathematical literacy.

8.13 The Emerging Significance of this Research

The principal contribution of this study lies in the fact that it has demonstrated that the implementation of mathematical literacy is undermined by the threat that qualified educators experience in relation to their identities as mathematics teachers. What is presented in the literature on the construction of teacher identity as a consequence of teacher subjectivities is not only largely absent in the literature on educational change (Carson, 2005), but also has few accompanying insights as to how a threat to the 'status-identity' affects and changes the lives of teachers in developing countries. This research extends the knowledge base on educational change into a new discipline and provides an insight that goes beyond the confines of the "institutionalized text" (Pinar et al., 1995) of the Mathematical Literacy curriculum.

I found that some of the problems been experienced by educators were such that teachers did not even have an awareness that these were so (required pedagogy of teaching mathematics in context). Others (history of learner ability) allowed teachers defenses with which to justify low learner outcomes and delivery of instructional material that did not support higher order knowledge and skills. Collectively, these issues were not been dealt with mainly for two reasons.

Firstly, the purpose of this new curriculum had not been understood in any considerable depth and consequently mathematics teachers were not significantly valuing the curriculum. And secondly, because the value of mathematical literacy was considered lesser than that of mathematics, qualified mathematics teachers teaching mathematical literacy were feeling a threat against their 'status-identity'. As an addition to the existing scholarship that thinly accounts for the importance of how teacher's personal and national histories engage with new equity circumstances to effect the desired change (Carson, 2005), I found that changes in subject disciplines also affect teacher identities.

A mathematics teacher attempting to add up the Mathematical Literacy curriculum not only has to come to terms with a new and variable concept of mathematics but also to make sense of what it means to be assigned the status of a mathematical literacy educator. To understand the concept of 'mathematical literacy' requires understanding not only on a deep level of the nature of mathematics but also of its transformative purpose and possibilities. It requires a deep understanding of the sudden shift from content, to context and content as a process, and a similar understanding of the motives behind the purpose and how the two interact within the new curriculum.

The struggle experienced by teachers in comprehending this interaction has connected teacher understanding of reform to understanding teacher 'status-identity'. Keeping in mind that South Africa is one of the first developing countries to mandate mathematical literacy in secondary schools as a discipline, this study extends the knowledge base on curriculum implementation into new contexts. For as Shulman & Sherin (2004:136) state, "if reform policy must be 'learning policy' (Cohen & Hill, 2001), then it must also be domain specific". These findings have revealed insights, some known and some as yet uncharted into the recurrent quandary of why it is so difficult to deeply change instructional practice.

APPENDICES

Appendix A

Ms H Sidiropoulos
32 Deutzia Rd.
Primrose Hill
1401

Fax: (011) 453 3177
E-mail: hsidiropoulos@saheti.co.za

Mr. Brown
Superintendent-General: Education
Gauteng Province
PO Box 7710
Johannesburg
2006

Dear Mr. Brown

Permission to conduct research in schools for PhD studies

I am studying towards a PhD in Policy Studies at the University of Pretoria. The focus of my study is implementing policy in a reforming, developing country context such as ours. The specific policy that is the focus of my study is the new Mathematical Literacy policy. As part of the research I need to collect data from schools. The data collection in two schools will involve questionnaires for Grade 10 mathematical literacy educators, interviews with these educators, observing their classrooms and document analysis. The results will inform both policy and practice. I have discussed this with some school principals who have given in-principle support. I therefore seek your permission to collect data from two schools as part of my doctoral studies. I promise to abide by the principles of anonymity and confidentiality.

Saheti School in Senderwood, Gauteng employs me as Head of Department Administration and Subject Head in Mathematics and Additional Mathematics.

Thank you,

Yours sincerely

Appendix B

Ms H Sidiropoulos
32 Deutzia Rd.
Primrose Hill
1401

Fax: (011) 453 3177
E-mail: hsidiropoulos@saheti.co.za

Dr. J. Kruger
Principal: FET High School
Gauteng Province

Dear Dr. J.Kruger

Permission to conduct research in schools for PhD studies

I am studying towards a PhD in Policy Studies at the University of Pretoria. The focus of my study is implementing policy in a reforming, developing country context such as ours. The specific policy that is the focus of my study is the new Mathematical Literacy policy. As part of the research I need to collect data from schools. The data collection in your school will involve a Grade 10 mathematical literacy educator answering structured questionnaires, my observing the said educator's classroom and interviewing the said educator. I will also need to look at records/documents of the educator and learners with regard to mathematical literacy. The results of the research will inform both policy and practice.

I therefore seek your permission to collect data from your school and educator from the 31 July to the 25 August 2006, and the week of the 9th of October 2006.I promise to abide by the principles of anonymity and confidentiality.

Thank you,

Yours sincerely

H.Sidiropoulos

Appendix C

DATA COLLECTION INSTRUMENTS

Research Questions:

1. What do teachers understand to be the purposes, problems and possibilities contained in the mathematical literacy curriculum?

2. How do teachers proceed to implement the mathematical literacy curriculum in their classrooms?

3. Why do teachers implement this curriculum in the ways they do? In other words, what explains the implementation pathways followed by the mathematical literacy curriculum in real classroom contexts?

Table of Contents:

SUMMARY OF RESEARCH QUESTIONS AND METHODS

The propositions are used as informative lenses for the data collection but may be refined and replaced depending on the data generated during the study. The relationship between the propositions and questions is theoretical and will be tested in this study.

RESEARCH QUESTIONS	PROPOSITIONS	METHODS
1) What do teachers understand to be the purposes, problems and possibilities contained in the mathematical literacy curriculum?	Teachers may not have a deep understanding of the purposes, problems and possibilities contained in the mathematical literacy curriculum.	○ Semi-structured interview with classroom teachers before classroom observation (Schedule C) ○ Questionnaire containing both open and closed ended questions (Schedule A) ○ In- depth document analysis of curriculum and related guidelines (Schedule G) ○ Researchers journal (Schedule J) ○ Theoretical analysis

2) How do teachers proceed to implement the mathematical literacy curriculum in their classrooms?	Teachers implement the mathematical literacy curriculum in their classroom using beliefs and pedagogies that are already entrenched in their practice.	○ Questionnaire containing both open and closed ended questions (Schedule B) ○ Analysis of teacher and pupil documents and records (Schedule F) ○ Classroom observation protocol (Schedule E) ○ Researchers journal (Schedule J) ○ Theoretical analysis

3) Why do teachers implement this curriculum in the ways they do? In other words, what explains the implementation pathways followed by the mathematical literacy curriculum in real classroom contexts?	Teachers implement mathematical literacy, as an alternative to mathematics, only because it is a mandatory subject, and in so doing avoid sanctions. Teachers do not embrace the 'spirit' of the reform.	○ Interview with teachers after the lesson (Schedule D) ○ Document summary form (Schedule H) ○ Questionnaire containing both open and closed ended questions (Schedule B) ○ Researchers journal (Schedule J) ○ Theoretical analysis

SUMMARY OF THE VALUE OF THE CHOSEN METHODS TO THE RESEARCH

CRITICAL QUESTION	METHOD	VALUE
1) What do teachers understand to be the purposes, problems and possibilities contained in the mathematical literacy curriculum?	Questionnaire schedule (survey)	This will provide me with information on how teachers understand the mathematical literacy curriculum, with respect to purposes, problems and possibilities.
	Interview schedule	The in-depth interview will enable me to elicit teachers' understanding of the curriculum. The open-ended questions will allow for the flexibility required in pursuing the 'gems' of information they may provide. The information elicited will also provide a basis for further refinement of the data instruments.
	Document analysis schedule (e.g. policy documents)	This information gathered will allow me to establish a comparison between the curriculum intentions and the teachers' understanding thereof.
	Researchers journal	The journal will be used to record my own views, perceptions and feelings, and in so doing provide me with a platform for reflection. It will also be used to capture non-verbal cues and emergent themes that can inform my design for subsequent interviews or observations.
	Theoretical analysis	Validating data by testing it against theoretical perspective.

2) How do teachers proceed to implement the mathematical literacy curriculum in their classrooms?	Questionnaire schedule	This will provide me with information on how teachers claim to implement mathematical literacy in their classrooms. It will capture the teacher's instructional practice, beliefs, and changes made
	Classroom observation protocol	This will provide me with direct evidence on the curriculum enactment in the classroom. This information will allow me to corroborate, refute and augment the evidence from the other sources.
	Document analysis schedule (e.g. lesson plans, learning programme guidelines)	This will allow me to gather evidence on the extent to which changes can be observed in the classroom practices.
	Researchers journal	The journal will be used to capture any critical incidents that occur in the classroom with respect to implementation that are not provided for in the interviews and questionnaires. Furthermore it will provide me with a record of my own bias on which I can reflect.
	Theoretical analysis	Validating data by testing it against theoretical perspective.
3) Why do teachers implement this curriculum in the ways they do? In other words, what explains the implementation pathways followed by the mathematical literacy curriculum in real classroom contexts?	Interview schedule	To gather information on why teachers pursue particular modes of curriculum implementation, and the 'spirit' of their instruction. This will be used to inform the explanation of the curriculum implementation pathway in the classroom.

	Document summary	These documents will reveal the discussions that took place prior to implementation. The information will reflect the decisions made and the reasons for these.
	Questionnaire schedule	This will allow me to gather evidence in order to establish why implementation occurred, and if these reason impact on the pathway followed by mathematical literacy in the context of the classroom.
	Researchers journal	To capture my perceptions of the 'spirit' of the lesson and the subject as enacted in the classroom.
	Theoretical analysis	Validating data by testing it against theoretical perspective.

SCHEDULE A

Questionnaire I

The purpose of this questionnaire is to collect information about teachers' understanding of the Mathematical Literacy curriculum and some background information.
The information you supply will be treated with absolute confidentiality and will be used for research purposes only.

PART A

EDUCATOR INFORMATION

PLEASE FILL IN OR CROSS (X) THE APPROPRIATE OPTION

1. Designation of educator

Teacher	Head of Department	Deputy principal	Principal	Other (specify)

2. Teaching subject area

Mathematics	Mathematical Literacy	Additional Mathematics	Other (specify)

3. List any other academic responsibilities

____

____

____

____

4. List duties other than academic

____

____

____

5. Age

Under 25	25-29	30-34	35-40	40-49	50-59

6. Teaching experience in years

0-5	6-10	11-15	16-20	20 or more

7. Gender

Male	Female

8. Formal qualifications

2 year diploma	3 year diploma	Degree only	Degree and diploma	More than one degree	Other (Specify)

9. Type of school

Primary	Secondary	Combined

11. Description of the school

Urban	Rural	Other (specify)

11. Does streaming (differentiation according to ability) occur in Mathematics classes?

Yes	No

12. Explain

___

___

___

PART B

The Mathematical Literacy curriculum in the Further Education and Training Band, Grade 10 came into effect in 2006.

The questions that follow inquire about the information available to you about the Mathematical Literacy curriculum, and two other related documents.

PLEASE FILL IN OR CROSS (X) THE APPROPRIATE OPTION

1. Are you aware of the Mathematical Literacy curriculum?

Yes	No

2. Was the document made available to your school?

Yes	No

3. If yes, please state how?

Workshop	Circular	Conference	Other (specify)

4. Do you have a personal copy of this curriculum statement?

Yes	No

5. How did you first become aware of the Mathematical Literacy curriculum?

I read the curriculum document	
I was informed about it by my Head of Department	
I was told by the principal	
I was invited to a workshop	
It was discussed at a staff meeting	
Other (specify)	

6. To what extent do you understand the Mathematical Literacy curriculum?

Not familiar	To some extent	To a large extent	Totally familiar

7. Does it provide guidelines for implementation?

Yes	No	Not sure

8. Does it allow for flexible implementation?

Yes	No	Not sure

9. Are you aware of the Learning Programme Guidelines for Mathematical Literacy?

Yes	No

10. Do you have a personal copy of this document?

Yes	No

11. To what extent do you understand the Learning Programme Guidelines for Mathematical Literacy?

Not familiar	To some extent	To a large extent	Totally familiar

12. Does it provide guidelines for implementation?

Yes	No	Not sure

13. Does it allow for flexible implementation?

Yes	No	Not sure

14. Are you aware of the Assessment Guidelines for Mathematical Literacy?

Yes	No

15. Do you have a personal copy of this document?

Yes	No

16. To what extent do you understand the Assessment Guidelines for Mathematical Literacy?

Not familiar	To some extent	To a large extent	Totally familiar

17. Does it provide guidelines for implementation?

Yes	No	Not sure

18. Does it allow for flexible implementation?

Yes	No	Not sure

PART C

What are your views about each of the following statements with regard to the Mathematical Literacy curriculum?

PLACE A CROSS (X) IN THE APPROPRIATE BLOCK

	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
1.The curriculum must be viewed in relation to the larger agenda of transformation					
2. The curriculum is mandatory because of political reasons					
3. The curriculum is mandatory because of the low levels of numeracy in the country					
4. It is a 'watered down' version of the more abstract Mathematics curriculum					
5. Is similar to the previous Standard Grade Mathematics curriculum in nature					
6.Is similar to the previous Standard Grade Mathematics curriculum in level of difficulty					
7. Is similar to the previous Standard Grade Mathematics curriculum in teaching					
8.Provides learners with an awareness and understanding of the role that mathematics plays in the modern world					
9.Allows for life-related applications of mathematics					
10.Enables learners to become numerically self-managing persons					
11. Enables learners to become contributing workers to society.					
12.Empowers learners with democratic participation					
13. Supports critical thinking					
14.Supports creative thinking					

PLACE A CROSS (X) IN THE APPROPRIATE BLOCK

	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
15. Delays formal methods (algorithms) in favor of extended opportunities to engage mathematics in diverse contexts					
16. Is suited to dealing with issues related to human rights, environmental and social justice					
17. Values indigenous knowledge systems					
18.Is credible in quality					
19.Supports only low order skills and knowledge					
20. Allows for no real abstract thinking only practical application					
21. Encourages team work in problem solving					
22. Respectfully considers and allows for diversity					
23.Favours process and context over content					
24.Conceptual knowledge is minimum					
25.The outcomes are of central importance to the attainment of the Critical and Developmental outcomes					
26.Is easy to implement					
27.Has resulted in anxiety and stress for you					
28.It is an opportunity for you to re-define your thinking about the nature and teaching of mathematics					
29.Informs and improves your teaching					
30.Allows for the development of knowledge, skills, values and attitudes					

PART D

How often do you use the following methods, tools and techniques in the teaching of Mathematical Literacy?

PLACE A CROSS (X) IN THE APPROPRIATE BLOCK

	Always	Often	Sometimes	Seldom	Never
1.Charts					
2.Tables					
3.Data from media					
4.Textbooks					
5.Scientific calculators					
6.Spread sheets					
7. Newspaper articles					
8.Computer software:					
▪ Autograph					
▪ Geometers Sketchpad					
▪ Other (specify)					
9.Debates					
10.Reflection					
11.Learner chosen contexts					

PART E

It is claimed that effective Mathematical Literacy teachers possess the following traits and behavior.

PLACE A CROSS (X) ON THE RESPONSE YOU CONSIDER MOST APPROPRIATE

	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
1.Have high but realistic expectations of all learners					
2.Promote and value learner effort					
3.Focus on key mathematical ideas					

PLACE A CROSS (X) ON THE RESPONSE YOU CONSIDER MOST APPROPRIATE

	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
4.Modify teaching as a result of lesson reflection					
5.Believe that mathematics teaching and learning should be enjoyable					
6.Are confident in their own knowledge of mathematics					
7.Vary their roles as teachers					
8.Connect mathematics ideas to various contexts					
9.Make the mathematical focus clear to the learners					
10.Use teachable moments as they occur					

PART F

WHAT DO YOU THINK ARE THE MAIN REASONS WHY THE MATHEMATICAL LITERACY CURRICULUM HAS BEEN INTRODUCED IN OUR SCHOOLS?

Please write clearly.

PART G

WHAT IS YOUR UNDERSTANDING OF THE TERM MATHEMATICAL LITERACY?

Please write clearly.

____

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PART H

DO YOU BELIEVE THAT TEACHING MATHEMATICAL LITERACY IS DIFFERENT TO TEACHING MATHEMATICS?

Please write clearly.

____

____

____

____

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____

____

____

PART I

WHO DO YOU BELIEVE SHOULD BE TEACHING MATHEMATICAL LITERACY?

Please write clearly.

PART J

WHAT DO YOU BELIEVE TO BE THE 'SPIRIT' OF THIS NEW REFORM IN MATHEMATICS? THAT IS WHAT ITS BROADER PURPOSE IS?

Please write clearly.

SCHEDULE B

Questionnaire II

The purpose of this questionnaire is to collect information about how teachers practice Mathematical Literacy in their classrooms.

PART A

PLEASE READ EACH OF THE FOLLOWING STATEMENTS BELOW WITH REGARD TO YOUR CURRENT TEACHING PRACTICE WITH RESPECT TO MATHEMATICAL LITERACY AND PLACE A CROSS ON THE NUMBER OF THE RESPONSE YOU CONSIDER MOST APPROPRIATE.

How does your current teaching practice match each of the following statements?

	Mirrors the statement	Room for improvement	Does not mirror the statement
1.Teaching is sensitive to indigenous knowledge systems			
2.Engages with real-world problems			
3.Various contexts are used			
4.Integrate lessons with other disciplines (subject areas)			
5.Entrepreneurial skills are targeted and developed			
6.Lessons engage learners critically			
7.Lessons engage learners creatively			
8.Basic mathematical skills are extended			
9.High levels of numerical skills are afforded			
10.Addresses issues of social justice			
11.Attitudes and values are developed			
12.Use technology			
13.Calculators used			
13.Reflection takes place (educator & learner)			
14.Pupils work in groups or pairs			

How does your current teaching practice match each of the following statements?

	Mirrors the statement	Room for improvement	Does not mirror the statement
15.Outcomes are linked to the Critical Outcomes			
16.Outcomes are linked to the Developmental outcomes			
17.Outcomes are the main objective of the lesson			
18.Outcomes overlap			
19.Process and context are the main elements of the lesson			
20.Content is the focus of the lesson			
21.Educator is confident			
22.Educator is motivated			
23.Assessment is integrated with teaching			
24.Feedback is integrated with teaching			

PART B

DO YOU THINK YOU HAVE THE NECESSARY KNOWLEDGE AND SKILLS TO IMPLEMENT THE MATHEMATICAL LITERACY CURRICULUM? PLEASE GIVE REASONS.

Please write clearly.

PART C

ARE RESOURCES IN TERMS OF TIME, MATERIALS AND HUMAN CAPACITY SUFFICIENT AT YOUR SCHOOL TO IMPLEMENT THE CURRICULUM? PLEASE EXPLAIN.

Please write clearly.

PART D

WHAT CHANGES WITH RESPECT TO YOUR TEACHING METHODS DID YOU MAKE IN IMPLEMENTING THE NEW CURRICULUM?

Please write clearly.

PART E

HAS YOUR UNDERSTANDING OF THE NATURE OF TEACHING MATHEMATICS CHANGED SINCE IMPLEMENTING THE NEW CURRICULUM?

Please write clearly.

PART F

HAVE YOUR BELIEFS WITH RESPECT TO WHO CAN DO MATHEMATICS CHANGED AS A RESULT OF MATHEMATICAL LITERACY?

Please write clearly.

PART G

WHAT DIFFICULTIES HAVE YOU EXPERIENCED IN THE IMPLEMENTING OF MATHEMATICAL LITERACY?

Please write clearly.

PART H

IN YOUR OPINION HOW CAN THESE BE OVERCOME?

Please write clearly.

PART I

HAVE YOU RECEIVED ANY TRAINING OR SUPPORT IN IMPLEMENTING MATHEMATICAL LITERACY? EXPLAIN.

Please write clearly.

PART J

IS MATHEMATICAL LITERACY ABOUT GAINING ACCESS TO MATHEMATICS OR ABOUT ACCESSING MATHEMATICS? EXPLAIN.

Please write clearly.

SCHEDULE C

Interview I (Pre-classroom observations)

1. What is your understanding of the Mathematical Literacy curriculum?
2. Why do you believe this subject was introduced?
3. Why do you think it was made compulsory?
4. Which of your students do Mathematical Literacy?
   - How was this decided upon?
   - Describe these pupils with respect to mathematical proficiency.
5. In your opinion can all learners do Mathematical Literacy?
6. What do you think is the status of the subject with respect to mathematics?
   - Do the pupils of the school share this view?
   - Do the parents of the school share this view?
   - Do your colleagues share this view?
7. What is your definition of mathematical literacy?
   - How did you arrive at the definition?
8. What in your opinion are the essential elements of mathematical literacy?
   - Why?
9. What do you think are the goals of the Mathematical Literacy curriculum?
10. How is your definition of mathematical literacy consistent with these goals?
11. What do you believe that being numerate requires?
12. What do you understand by the following terms:
    - acquiring mathematical methods
    - establishing mathematical understanding
    - establishing mathematical connections?
13. Do you think you have a role to play in this mathematics reform?
    - What role?
14. What are the advantages of offering Mathematical Literacy?
15. What are the disadvantages of offering Mathematical Literacy?
16. Why did you introduce Mathematical Literacy at your school?
17. How does the Mathematical Literacy curriculum differ from the new Mathematics curriculum?
18. How does the Mathematical Literacy curriculum differ from the old Standard Grade Mathematics curriculum?
19. How does teaching the Mathematical Literacy curriculum differ from teaching the new Mathematics curriculum?
20. How does teaching the Mathematical Literacy curriculum differ from teaching the old Standard Grade Mathematics curriculum?
21. Do you believe that Mathematical Literacy will improve numeracy levels in your school?
    - Why?
22. Do you believe that Mathematical Literacy will improve numeracy levels in the country?
    - Why?

23. Do you feel confident with respect to teaching Mathematical Literacy?
    - Why?
24. Are you motivated to teach this subject?
25. How did you go about implementing this new curriculum?
    - Did you have any support?
    - Did you receive training?
26. What difficulties have you experienced with the implementation process?
27. What difficulties do you think teachers nation wide have experienced in the implementation process?
28. Have you had to change any of the following:
    - teaching style
    - teaching methods
    - beliefs with respect to the nature of mathematics?
29. What are your short-term goals with respect to teaching Mathematical Literacy?
30. What are your long-term goals with respect to teaching Mathematical Literacy?

SCHEDULE D

Interview Schedule II (Post-lesson observation)

The purpose of this questionnaire is to briefly collect information about how teachers perceive the nature of the lesson they have just delivered.

1. What was the purpose of this lesson?
2. In your view was this a successful lesson? Why?
3. Do you believe that the pupils acquired the knowledge and skills you expected of them before the lesson? Explain.
4. In future would you do anything differently? Explain.

SCHEDULE E

Classroom Observation Protocol

(4 weeks continuously of 1-hour lessons followed by one more week after 6 weeks)

Teacher:

School:

Date:

	Lesson ___		Lesson ___		Nature of use/Comments
	Yes	No	Yes	No	
1.Purpose of lesson explained to learners					
2.Pre-knowledge determined					
3.Teaching supports learners to take ownership of mathematics					
4.Context obscures mathematics					
5.Use of authentic contexts					
6.Context familiar to learners					
7.Contexts used are a priori					
8.Contexts used are inductive					
9.Guided discovery of algorithms					
10.Learners encouraged to seek mathematical understanding					
11.Solution process varied and rich					
12.Mathematical 'life skills' taught					
13.Mathematical reasoning (justification) encouraged					
14.Reflect on solutions - awareness only					
15.Reflect on solutions- consensus generation					
16.Adaptive/differentiated instruction					
17.Instructional expectations of learners high					
18.Development of attitudes and values					

	Lesson ___		Lesson ___		Nature of use/Comments
	Yes	No	Yes	No	
19.Teaching practice (pedagogy) promotes self-regulated learning					
20.Consolidate basic skills					
21.Extend basic skills					
22.Critical analysis of problems					
23.Critical engagement with regard to mathematical arguments					
24.Creativity in solving allowed for					
26.Lessons afford depth					
26.Lessons afford breadth					
27.Indigenous mathematics problems/examples used					
28.Communicates using various methods					
29.Variety of teaching resources used					
30.Multiple forms of representation (e.g. tables, diagrams)					
31.Computational tools used					
32.Space, shape & measurement using design/art/ geography/ other					
33.Functional relationships (rate of change)					
34.Numbers & operations in various contexts					
35.Data handling-awareness of data manipulation					
36.Data handling-critical analyses					
37.Learners pose/identify problems					
38.Recognition provided					
39.Reinforcement given					
40.Motivational strategies used					
41.Positive attitude towards all learners					

	Lesson ___		Lesson ___		Nature of use/Comments
	Yes	No	Yes	No	
42.Informed feedback given					
43.Outcomes focused					
44.Content focused					
45.Teacher -centered					
46.Learner-centered					
47.Collaborative problem solving					
48.Instructional match (needs to instruction matched)					
49.Order of lesson-review previous material, demonstrate how to solve problems for the day, practice similar problems					
50.Responsibility/sensitivity to broader societal concerns					
51.Career opportunities discussed					
52.Entrepreneurial success discussed					
53.Learners reflect on lesson					
54.Teacher reflects on lesson					
55.Assessment integrated in instructional practice					
56.Process and context interrelated with content					
57.Ownership of curriculum					
58.Relates mathematics to other learning areas					

SCHEDULE F

Document analysis I

PART A

Analysis of Learner Documents and Records

Criteria	Books/notes	Portfolios	Reports of learners	Comments
Purpose of lesson obvious				
Real-world problems				
Variety of contexts used				
Contexts chosen by teacher				
Evidence of learner context choices				
Focus is on content				
Focus is on process				
Evidence of issues related to human rights, environmental, social justice				
Reflects indigenous knowledge systems				
Conceptual knowledge developed				
Individuals needs catered for				
Lesson integrates with other disciplines				
Various methods of communication				
Use of calculators				
Estimation				
Use of technology				
High knowledge problems set				
High skills problems set				

PART B

Analysis of Educator Documents and Records

Criteria	Subject framework	Work schedule	Lesson plans	Departmental minutes	Staff development documentation	Comments
Philosophy and policy						
NCS principles						
Conceptual progression						
Integration of LOs & ASs						
Resources- learning & teaching						
Inclusivity & diversity						
Assessment						
Contexts & content						
Teaching methodology						
Learning methodology						

SCHEDULE G

Document analysis II

Three documents i.e., National Curriculum Statement Mathematical Literacy, Learning Programme Guidelines Mathematical Literacy, an Subject assessment Guidelines Mathematical Literacy, will be analyzed with respect to purpose, principles, scope and opportunity.

The documents will be explored and summarized according to the following criteria:

1. What is the purpose of the document?
   - What is the rationale for the document?
   - What are the goals and objectives of the document?
   - What principles is the document based on?
   - What are the implied intentions of the document?

2. How is the document related to transformation?

3. What is the 'theory of action'?

4. Which themes emerge?

SCHEDULE H

Document analysis III

The purpose of this summary form is to collect any additional information pertinent to this study from auxiliary (subject files, vision statement for implementation, timetable etc.) educator documents.

Site:____

Document number:_____________________________

Date received or picked up:______________________

Name or description of document:

EVENT OR CONTACT, IF ANY, WITH WHICH DOCUMENT IS ASSOCIATED:

SIGNIFICANCE OR IMPORTANCE OF DOCUMENT:

BRIEF SUMMARY OF CONTENTS:

SCHEDULE I

Contextual Information on the School

The purpose of this checklist is to collect contextual information on the school in order to compile a vivid and rich description of the case study school for the narrative of this research.

To be completed by the researcher/teachers in the school

PLEASE FILL IN OR PLACE A TICK IN THE APPROPRIATE COLUMN

1. Type of building

a) Building designed as school	
b) Prefab	
c) Teacher training college	
d) Other (specify)	

2. School building

a) Number of blocks	
b) Number of storeys	

3. Condition of school and furniture

	Type of structure: Specify (e.g., brick wall, tile roof, etc)	No maintenance needed	Need maintenance	Need maintenance & structural repair	Beyond repair
a) Roof					
b) Windows					
c) Doors					
d) Walls					
e) Furniture					
f) Floors					
g) Toilets					
h) Ceilings	Fitted	Not fitted			
i) Other (specify)					

4. Number of toilets for teaching/administrative staff

a) Male staff	
b) Female staff	
c) Out of order	

5. Number of toilets for learners

a) Males	
b) Females	
c) Out of order	

6. Power and energy supply

a) Wired & supplied with electricity	
b) Wired but not supplied with electricity	
c) Not wired and/or & no electricity available	
d) Generators	
e) Other (specify)	

7. Overall condition of building

Very weak (not suitable for occupation)	Weak (structure needs attention)	Needs paint & minor repairs	Good condition	Excellent, no foreseeable repairs

8. Safety

a) Building is completely fenced with security at the entrance	
b) Building is completely fenced without security at the entrance	
c) Building has been fenced but fence is damaged	
d) No fence	
e) Other (specify)	

9. Office space

	Adequate	Inadequate	None	Estimated shortfall number
a) Offices for management				
b) Offices for admin staff				

10. Access roads

	Good condition	Poor condition
a) Tar road		
b) Gravel road		

11. Please provide a general description of the overall surroundings

SCHEDULE J

Researchers Journal

Date:
Day:
Time:

RESEARCHER REFLECTIONS

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