

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 (Spillane *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' than 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, 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*).

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 than 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 they 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 Michaels¹¹, 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.