MATHEMATICS TEACHER LEARNING, COMMUNITIES OF PRACTICE AND THE CENTRALITY OF CONFIDENCE

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DECLARATION

I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Mellony Holm Graven

28th day of February 2002

ABSTRACT

This study investigates mathematics teacher learning in relation to teachers' participation in an In- Service Education and Training (INSET) programme, structured to enhance participation in a community of practice, in the context of current South African curriculum change. The study confirms that teacher learning in in-service contexts is a social process that demands a socio-cultural perspective to do justice to the complexity of social factors influencing it.

The methodological approach of the study is 'interpretive qualitative research' that draws on a range of methods with their roots in case study research, grounded research and ethnography. In the research I take on the dual role of both researcher and co-ordinator of the INSET programme and thus am both 'observer as participant' and 'participant observer'.

The study focuses on explaining the learning mechanisms by which teachers become professional and confident mathematics teachers through participation in an INSET community of practice that overlaps with a wide range of other professionally associated communities (such as the school communities and professional associations). The study illustrates through rich and textured vignettes and quotes, that teachers' participation in the INSET community of practice involved the complex intersection of various components of learning, namely: meaning (learning as experience), practice (learning as doing), identity (learning as becoming), community (learning as belonging) and confidence (learning as 'mastery').

A central contribution of the study is a social construction of confidence in relation to learning as participation and becoming and the location of this in the context of learning to become a professional mathematics teacher. Other contributions include:

- analysing the current South African curriculum change process (and in particular mathematics curriculum change) in terms of the implications this has for both teacher roles and identities, and for teacher education;
- the problematisation and theorisation of what it means to research teacher learning from 'the inside' of an INSET practice;
- the problematisation and theorisation of dilemmas in the design of INSET programmes in the current South African context;
- the application, critique and extension of current literature relating to learning as participation in a community of practice in the context of teacher learning.

DEDICATION

In memory of my mother Annette Maria Graven

You’ve been my inspiration
Through the lies, you were the truth
My world is a better place because of you.

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John Mason (1998) writes that the most significant products of research are the transformations in the being of the researcher. To everyone below I say thank-you for your part in supporting, motivating and stimulating the enormous transformations that I have undergone, through my engagement and participation with you, during this process.

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A note in relation to the above acknowledgements:

This research study has been conducted at the University of the Witwatersrand under the doctoral research programme run by Professor Jill Adler and Professor Paul Laridon. In 1998 they began a doctoral research programme in mathematics education in which they created a community of practice of doctoral research students from all over Southern Africa.

Participating in this ‘doctoral practice’ involved discussion and debate with a wide range of colleagues in the field of mathematics education including fellow doctoral students, supervisors, guest speakers and visitors from foreign institutions. It involved presenting work to colleagues at local and international seminars and conferences. The practices I engaged in therefore offered me access to a wide range of resources. Most importantly this offered me the opportunity to engage critically with colleagues who have a grounded understanding of research and education in the South African context.

It is important to emphasise this because the decision to do this research study at a South African University, with a supervisor with expertise and experience in research in Education in the South African context, was not accidental or shaped by mere convenience. This study both demanded a local support base and is a product of this support base. I believe this local base has:

- enabled the research agenda to be developed in South Africa;
- provided access to ongoing critical engagement with supervisors, fellow students and colleagues with in-depth knowledge of the issues that confront researchers in the Southern African educational contexts and an in-depth knowledge of local related literature;
- enabled longer term research with easy access to the research participants for follow up interviews or questions for clarification;
- supported me to expand my 'community of practice' to include Southern African and international communities of practice;
- enabled me to develop a strong sense of my own identity as a South African researcher with a clear research agenda.

In this, I am privileged to have had access to this local support base while simultaneously being supported to share ideas internationally and to gain from international perspectives. In the same way as this study yields useful insights into teacher learning in relation to participation in an INSET community of practice, I believe that research on doctoral students learning through participation in communities of practice would usefully inform educators involved in the development of education researchers.

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NOMENCLATURE

AMESA – Association for Mathematics Education of South Africa

GDE – Gauteng Department of Education

GICD – Gauteng Institute for Curriculum Development

HOD – Head of Department

ILP – Illustrative Learning Porgramme

INSET – In-service Education and Training

LAC – Learning Area Committee

LLC – Language, Literacy and Communications

MLMMS – Mathematical Literacy, Mathematics and Mathematical Sciences

NDE – National Department of Education

NECC – National Education Coordinating Committee

NGO – Non Government Organisation

NUE – National Union of Educators

OBE – Outcomes Based Education

PLESME – Programme for Leader Educators in Senior-phase Mathematics Education

PRESET – Pre-service Education and Training

PRF – Pedagogic Recontextualising Field

OPRF – Official Pedagogic Recontextualising Field

RADMASTE – Centre for Research and Development in Mathematics, Science and Technology Education, University of the Witwatersrand

SAARMSE – Southern African Association for Research in Mathematics and Science Education

SAARMSTE - Southern African Association for Research in Mathematics and Science Education

SADTU – South African Democratic Teachers' Union

SAQA – South African Qualifications Authority

SO – Specific Outcome

TSUD – Teacher Supply Utilisation and Demand strategy

UPRF – Unofficial Pedagogic Recontextualising Field

Chapter 1: Contextualising the Study: Introduction, Rationale and Overview

The particularity of the current post-apartheid South African context, which is characterized by a society in transition undergoing massive transformation and restructuring in all sectors, including education, cannot but shape any current research into education in South Africa. If research is intended for both a local and international audience then it has to begin with a detailed picture of the current state of education, and with an analysis of the process of curriculum change.

In this chapter I explain the significance of this study, the purpose of the study and the dynamic context within which the study takes place. This chapter is divided into three parts:

Part 1: The Rationale and Purpose of the Study
Part 2: The Context of South African Curriculum Reform
Part 3: An Overview of the Study.

Part 1: The Rationale and Purpose of the Study

For several years I have worked in mathematics INSET projects aimed at keeping teachers up-to-date with developments in mathematics education. While there were some successes in these projects, there was often little change in teacher practices. When this study began intensive curriculum change was in process. My experience in in-service teacher education, and the context of the implementation of radical curriculum change, inspired me to conduct research relating to teacher learning in INSET in the context of curriculum change.

The purpose and critical questions of the study

The purpose of this research is to investigate mathematics teachers' learning (through participation in an INSET Programme, structured to enhance participation in a community of practice) in relation to current South African curriculum change.

The original questions of the research (as stated in the research proposal) related to how teachers interpreted and enacted the new curriculum, how they participated in an INSET community of practice and the implications of the study for models of mathematical INSET. As the research proceeded, new organising questions emerged, and the original questions, through this, became sub questions of the following two critical questions:

- To what extent is social practice theory (in particular the work of Lave & Wenger, 1991 and Wenger, 1998) helpful in explaining the nature of teacher learning in relation to their participation in a mathematics INSET project?
- What is the role of 'confidence' (as commonly referred to by PLESME teachers in explanations of their learning) in mathematics teacher learning and how should 'confidence' be constructed and understood from a social practice (as opposed to a psychological) perspective?

Less central but important questions include:

- What are the limitations of applying a perspective of learning as participation in a community of practice to teacher learning? How should Wenger's (1998) work be extended in the context of teacher education?
- Where does 'confidence' fit in relation to Wenger's (1998) model of learning?
- How do teachers interpret and enact new aspects of mathematics education over time?
- To what extent and how do teachers participate in, and make use of, a community of practice, stimulated by INSET, in a context of curriculum change?
- What are the implications for models of INSET based on a community of practice perspective of learning?
- What is the nature of the relationship between new teacher roles (as inscribed within new education policy and the new mathematics curriculum) and emergent teacher identities?
- How do individual teacher trajectories (especially as relates to mathematical background) impact on their implementation of new curriculum ideas in the classroom?

There are three features specific to this research that distinguishes it from other research relating to mathematics teacher education. First, it is about teacher learning *within INSET* (not PRESET which has in the past dominated teacher education literature). Secondly, it is a specific type of INSET that aims to enhance participation in a *community of practice* (i.e. it draws on social practice theory). And thirdly, it is conducted within (and takes cognisance of) the context of *rapid curriculum change* in a post-apartheid South Africa.

Why the study focuses on *INSET* in the context of *curriculum change?*

For the past seven years I have worked at the University of the Witwatersrand running various in-service projects for mathematics teachers and conducting impact-type research on these projects. The nature of my work therefore encouraged a duality between my role as INSET provider and as a researcher. In this sense the focus on teacher learning within INSET in the context of curriculum change was both opportunistic and practical, although there are of course many arguments for why research of this nature is important especially given the current South African context.

As importantly, the National Department of Education has prioritised teacher education and specifically *mathematics* teacher education in recent years. However it is acknowledged that little is known about which models for teacher education work or why they work. As described in Part 2 of this chapter, the low numbers of qualified mathematics teachers and the implementation of radical curriculum reform have created great demand for mathematics INSET in South Africa. While evaluation studies have been conducted on various Mathematics Teacher Education INSET projects in South Africa at the Senior Phase level (Adler, 1995; Graven, 1997, 1998; Taylor & Vinjevold, 1999), these have generally been conducted prior to the implementation of the new curriculum. (Implementation at senior-phase level began only in 1998). These previous studies have therefore not produced rich qualitative data on the nature of teacher learning in relation to current curriculum change. Rather they have produced some insights into various obstacles that might impede teacher development and insights into aspects that might enhance teacher development. Thus, there is currently little published research on

mathematics teacher learning in relation to teachers making sense of the new curriculum called 'Curriculum 2005'[1].

In conjunction with the call for increased INSET for teachers in relation to Curriculum 2005, there is also a plea for research on the implementation process (Chisolm *et al*., 2000; Kahn, 2000) and for research which explores different models of teacher education so as to examine which type of projects succeed and why (Kahn, 2000). Dr Toale, director of the National Research Foundation of South Africa, argues that the new curriculum requires a new research culture. This new research culture should be characterized by long-term studies that incorporate a full range of components of the education system and must seek to understand the interplay amongst these components (Toale, 2000). Kahn (2000) suggests that contextual factors must be central to research since what works in some schools (or countries) might not work in others. All of this implies a need for research in a wide range of contexts in South Africa.

This study provides research relating to teacher learning in a specific context, that is urban township mathematics teachers involved in a community of practice-based INSET project. Dickinson (2001) argues that in the case of national research questions (for example, what INSET models are appropriate for South Africa?) 'multi-locale research' is essential and enables linking 'events' at the macro and micro level. This study contributes to that wider research question while acknowledging the importance of research in different contexts.

Similarly, increased teacher development *internationally*, has created a need for more research on the process of in-service teacher learning. Wilson & Berne (1999) note that there is still much to be learnt in the field of teacher learning:

> Concurrent with this call for more professional development has been a call for more research on teacher learning. Yet what the field "knows" about teacher learning is rather puzzling. In part this is due to the scattered and serendipitous nature of teachers' learning… As a field, we know very little about what teachers learn across those multiple opportunities (pp.173-174).

[1] The nature of this curriculum is discussed in detail in Chapter 2 of this study.

Furthermore the changing nature of INSET calls for new research. Nelson (1997) points out:

> We have not yet achieved a coherent theory of teacher change, though there are promising movements in this direction. And there are a large number of practical issues yet to be addressed (p.411).

The broader field of research on teacher learning is thus in need of in-depth research in different INSET contexts in order to generate a coherent theory of teacher learning. Contributions from developing countries usually lag behind in this respect. There is therefore the risk that a skewed perspective, dominated by research conducted in first world countries such as the USA and Britain, could result.

Kahn (2000) notes that the bulk of research on curriculum change is from OECD[2] countries and cannot easily be extrapolated to developing countries. South Africa is a developing country embarking on large-scale radical curriculum change. It therefore provides a useful opportunity for conducting rich qualitative research on the process of teacher learning in relation to curriculum change in contexts very different from those of the prevailing literature.

Nelson (1997) notes that the range of empirical case studies in 'rich sites' is helping to reconceptualise the nature of teaching itself. She also notes that it is important that we begin to flesh out what the nature of teaching is when teachers take on new roles and practices as stimulated by curriculum change. There is a need for qualitative long-term research which puts the teacher at 'centre stage' (Nelson, 1997) and analyses, from the inside of teachers' professional worlds, the processes and dilemmas which teachers go through as they attempt to develop their practices so as to incorporate new mathematical curriculum ideas. This research can then contribute to curriculum decisions, development of INSET programmes and stimulate debate among teachers and educators.

Why research teacher learning in a *community of practice-based* INSET model?

[2] OECD is the acronym for the Organisation for Economic Co-operation and Development.

At the start of the research I expressed an interest in investigating mathematics teachers' learning in relation to an INSET programme that was structured to enhance participation in a community of practice. Thus from the start of the research and PLESME I held the assumption that teacher learning would be enhanced by stimulating participation in a community of practice. This assumption was influenced by the work of Lave & Wenger (1991). For them, learning is a way of being in the social world and not a way of coming to know about it. Learning is a process of becoming, of changing participation and changing identity within a community of practice (Lave & Wenger, 1991). This central theme of the study is discussed in more detail in Chapter 5.

In Chapter 3, I describe how from early analysis of initial teacher interviews, questionnaires and journal entries I was drawn to ideas of learning as becoming and learning as changing identity. Teachers were talking about their learning in terms of becoming someone different. Since this resonated strongly with the work of Lave & Wenger (1991) and later with the work of Wenger (1998) I drew on these works for the core theoretical framework of this study. This framework influenced the nature of the research and indeed the nature of PLESME.

Lerman (2001) critiques a range of dominant research traditions in teacher education. He notes that there has been considerable recent interest and development in research on teacher education. He argues that in terms of the complexity of the field, theoretically and empirically, there is still much to learn. He critiques the predominant orientation of this research towards 'teacher beliefs' and notes an absence of discussion of the *process* of change, which, as in this study, he prefers to call learning, in relation to teacher beliefs. The 'mechanics' of such processes, he stresses, need to be unpacked.

Lerman (2001) furthermore critiques the inadequacy of reflective practice (which assumes reflection is sufficient to evoke learning) and constructivism (for its focus on the individual rather than on issues of social relations and power) as theories for explaining teacher learning. He argues rather for the use of other research perspectives that locate 'teachers in their contexts' (p.17). One such perspective is a community of practice model (Lave, 1998; Lave & Wenger, 1991; Wenger, 1998). He notes that there are few teacher education programmes, or research on

teacher education, that draw on Lave's (and Lave & Wenger's) ideas and that there are aspects of their work that need further development by researchers.

In this study I have identified several aspects of Wenger's (1998) work that need development for application in the context of teacher education and several 'gaps' in the work which need extension and exploring. Clearly, while Lave & Wenger (1991) and Wenger (1998) have reconceptualised learning, they have not reconceptualised the meaning of teaching and its relationship to the developing identities of teachers. Perhaps this is not their project, or perhaps the case of teacher learning presents a special context for interrogating the applicability of their theory. Several other gaps are identified in this theoretical body of work in the context of applying it to teacher education. These will be discussed further in Chapter 5. Suffice to say that a central part of the rationale for this study is its intention to contribute to this body of literature, and its application in the context of teacher education.

In summary, the contribution of this study is practical, theoretical and methodological.

Practically, research on the process of teacher learning within a range of models of teacher education is essential in the current South African context. Similarly, the increase of INSET projects and changes to the nature of INSET models internationally demand that extensive research be conducted in relation to these models. This research seeks to make an important contribution to this international research from a developing world perspective.

Theoretically, literature that analyses teacher learning from a perspective of participation in a community of practice and 'learning as becoming' is relatively new (see Gomez, 2000; Bohl & Van Zoest, 2001; Stein & Brown, 1997). This literature needs further development and critique. Critique of this nature needs to be sustained and developed through attempts to apply these perspectives to a range of research studies in many different contexts. It is in this respect that this research seeks to make a useful theoretical contribution.

Methodologically, as will be shown in Chapter 4, it has been necessary to draw on a wide range of research methods from several methodological traditions. Furthermore it was necessary to

focus on a range of issues concerning ethics, reliability, validity, generativity and generalisability in relation to this study. This study seeks to offer insight into an approach to researching INSET in which the researcher is simultaneously a central part of that INSET.

Part 2: The Context of South African Curriculum Reform: Changing Curriculum for a Changing South Africa

> *Setting out what a nation thinks all students should learn is a major political exercise. It is a direct statement of what the society believes schooling is about* (Malcolm, 1999, p. 87).

In this section I describe the changing curriculum in South Africa in general terms. That is, I examine the political, economic and social contexts in which educational change is taking place, the nature of curriculum change for schools, the underlying theoretical assumptions of this change, and the changing roles of teachers within this context.

Providing the broader context within which the study is conducted is important since it provides the background against which this study emerges, is conducted, and should be interpreted.

South Africa: a heritage of inequality

South Africa has been typified by large inequalities. Wilson & Ramphele (1989), note that of the 57 countries for which data is available, South Africa displayed the widest gaps between rich and poor. The system of apartheid was predicated on ensuring that these inequalities were structured along racial lines. Under apartheid four racially classified population groups were created, namely: White (of European origin), Coloured (of mixed race mainly European, African and Malaysian), Asian (of Asian origin) and African (of African origin). All South Africans, not designated as 'White' were denied democratic participation and resources were allocated differentially for services such as Education, Health, and all the essential services. Thus, huge inequalities were created and perpetuated under apartheid resulting in large gaps between the rich and largely white population, and the poor and largely black population.

These inequalities extend into Education. At the time of the first democratic elections seventeen Education Departments existed in South Africa each with its own different budget (Taylor & Vinjevold, 1999). The continued dominance of English as the language of power, commerce, government and education reinforces these inequalities. The 1996 census showed that only 8,6% of South Africans cited 'English' as their primary language (Adler, 2001). Thus the majority of South African learners are learning in a language that is not their primary language. It is widely noted by educators (Jansen, 1999; Taylor & Vinjevold, 1999; Adler, 2001) that understanding such inequalities is crucial to understanding the context of education and of educational change in South Africa.

Post -1994 South Africa has held two democratic elections and while moderate economic growth has been achieved, the levels of economic growth required to redress the imbalances of apartheid have not been reached (Dickinson, 2002). Streek (2002) reports that more than 45% of South African schools are still without electricity, while more than 27% are still without clean water and 66% are without adequate sanitation. Streek (2002) writes:

> Minister of Education Kader Asmal outlined in a speech in the National Council of Provinces last May what progress had been made in reducing inequality in the country's schools, but then admitted that 'the backlog is still huge and the differentiation between rich and poor schools within the public system is still unacceptable'. The reality is that after nearly eight years of democratic rule, gross inequality, largely racially and poverty-based, remains in the schooling system (p.7).

Thus while the South African constitution states that everyone has the right to basic education, there are vast differences between what 'basic education' involves for different groups of students.

The context of educational change in which school curriculum change is located

South Africa is currently embarking on radical educational reforms. The need for a complete overhaul of the education system has been identified as a major priority for the building of a new democratic South Africa. Thus educational change has been stimulated by the major political changes, which occurred in the country during the 1990s. Throughout the 1990s, debates in education were raging as to how to develop an education system that ensures greater accessibility for all to education, redresses inequalities, enables and encourages democratic citizenship and which enables articulation between vocational and formal education.

The vision for education that emerged from these debates was to integrate education and training into a system of lifelong learning. A co-ordinating structure, the National Qualifications Framework (NQF), was designed to integrate education and training in such a way that equivalence could be determined between them and so enhance access and mobility for learners (Baxen & Soudien, 1999). This equivalence would be enabled through outcome statements (Christie, 1999). Typically, outcomes describe what learners must know, understand, be able to do, or be like (Willis & Johnston, 1998). Outcomes-based education (OBE) was adopted as the system that would enable the articulation between education and training, recognition of prior learning and thus increased mobility for learners.

There has been much confusion between the new curriculum (called Curriculum 2005) and outcomes-based education (commonly referred to as OBE). Curriculum 2005 has three distinctive sources, each with its own contribution. These are a philosophy of learner-centred education, outcomes-based education and an integrated and non-disciplinary approach to the division of knowledge (Chisolm *et al.,* 2000). Curriculum 2005 therefore includes principles of learning that are not necessarily principles of OBE. However for most of the public and for teachers, OBE and Curriculum 2005 are seen as interchangeable names for the new curriculum (Chisolm *et al.,* 2000).

South Africa's approach to OBE has been influenced by the approaches of Australia, America and Canada but has also been 'indigenised' (Harley & Parker, 1999). South Africa's OBE is

heavily learner-centred and reflects a hybridisation of different versions of outcomes-based and competence-based models of education (Harley and Parker, 1999). The National Department of Education (1997a) explains OBE as follows:

> Outcomes-based education is a flexible, empowerment-oriented approach to learning. It aims at equipping learners with the knowledge, competence and orientations needed for success after they leave schools or have completed their training. Hence, its guiding vision is that of a competent future citizen (p.21).

South Africa's version of OBE has its own specificities and intentions that relate to its broader political aims. According to Mohamed (1999), South Africa's introduction of outcomes-based education is intended to 'provide a qualitative system in terms of relevance, learner-centredness, critical thinking, economic growth and development, social responsibility, integration and *ubuntu*[3] (p.158).

It is important to recognise that curriculum change in schools is not being implemented in a context of stability but within an education system that is developing and in a state of flux. It is within this context of the restructuring of education and the restructuring of South African society in general that curriculum change in schools takes place.

Curriculum 2005 as the vehicle for educational and social change

Curriculum 2005[4] was launched in March 1997. The name 'Curriculum 2005' was chosen because it indicated the curriculum would be implemented in all grades by the year 2005. Implementation would be staggered. Curriculum 2005 applies to all bands of education, that is to Early Child Development (ECD), General Education and Training (GET, Grades 0-9), Further Education and Training (Grades 10-12) and Adult Basic Education and Training (ABET).

[3] The word 'ubuntu' is a Zulu word that is widely used in South Africa to refer to 'goodwill' or 'community spirit'.
[4] In this chapter, and in Chapter 2, I mainly discuss Curriculum 2005 as 'intended' curriculum. This should not imply that I define curriculum simply in policy terms. Rather I view curriculum as a contextualised social process (Cornbleth, 1990), in which the intended official curriculum and the implemented received curriculum (Kelly, 1993) are interwoven. In Chapter 6 and Chapter 7 I analyse teacher implementation of new curriculum ideas.

Currently however detailed curriculum documents are only available in the GET band (Chisolm *et al.,* 2000).

This curriculum is premised on a learner-centred, outcomes-based approach to education. The key principles on which Curriculum 2005 is based are: integration, holistic development, relevance, participation and ownership, accountability and transparency, learner-oriented, flexibility, critical and creative thinking, progression, anti-biased approach, inclusion of learners with special education needs and quality standards and international comparability (National Department of Education, October 1997).
It should be noted that these changes in education did not originate in Curriculum 2005. South Africa has a long history of attempts to introduce 'alternative curricula', most notably the People's Education movement and the National Education Co-ordinating Committee[5]. Chisolm *et al.* (2000) sums this up:

> During the apartheid years the principal pedagogical alternative to the education system's Fundamental Pedagogics was 'progressive education,' a form of learner-centred education nurtured in the liberal universities and the English private schools. In the 1980s the progressive learner-centred approach was linked to an egalitarian transformative project for South African education, and the result, People's Education, was presented as the alternative to 'apartheid education' (p.26).

The effectiveness of these attempts was however muted and the curriculum of the apartheid state clearly dominated (Jansen, 1999b). With the changes in the political landscape opportunities were opened for progressive education stakeholders to become involved in policy debates about the future of education. The main features of people's Education that were absorbed into contemporary policy were equal access for all, critical thinking, learner-centredness, bridging the gap between theoretical and practical knowledge, teachers as curriculum developers, group work, community participation and continuous assessment (Kraak, 1999; Chisolm *et al.*, 2000). It is

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[5] The NECC was an alliance of progressive education and labour stakeholders. In 1992 its Curriculum Research Group produced a National Education Policy Investigation (NEPI) report on curriculum on which much of the current curriculum is based.

interesting to note that outcomes-based education was not part of the discourse of the NECC or People's Education (Jansen, 1999b). OBE influences can be traced back to the competency-based discourse that was popular in training circles. With discussions between labor and business 'competences' became transmuted into 'outcomes' (Chisolm *et al.*, 2000). Kraak (1999) argues that the increased popularity of OBE in South Africa can be ascribed to its skilful packaging in the radical discourse of People's Education.

I will focus my discussion of Curriculum 2005 on the GET band since this is the only band currently available and is the band that relates to this study. In the GET band the previously tightly bound subjects (disciplines) are re-organised into eight learning areas, which are broader and more integrated than previous subjects, namely: Language, Literacy and Communication; Mathematical Literacy, Mathematics and Mathematical Sciences; Human and Social Sciences; Natural Sciences; Technology; Arts and Culture; Economic and Management Sciences; and Life Orientation. Furthermore, Curriculum 2005 emphasises a move away from examination dominated forms of assessment to the use of continuous assessment and provides a 'complex matrix' of range statements, assessment criteria and performance indicators from which teachers should construct learning programmes (Christie, 1999).

The general framework of Curriculum 2005 has an overarching set of critical outcomes and specific outcomes in eight learning areas. The critical outcomes address competencies of the form that 'learners will', for example, communicate effectively, solve problems and make responsible decisions using critical and creative thinking (Malcolm, 1999).

An important feature of Curriculum 2005's use of OBE is the inclusion of specific outcomes in each of the eight learning areas that overtly address social, cultural and political issues that resonate with the broader political aims of the creation of a democratic South Africa. For example, in the learning area of Mathematical Literacy, Mathematics and Mathematical Sciences (MLMMS), specific outcome number four is: 'critically analyse how mathematical relationships are used in social, political and economic relations'. In the learning area of Human and Social Sciences, specific outcome number three is: 'participate actively in promoting a just, democratic

and equitable society' (NDE, 1997). As in the case of Australia, South Africa's OBE has a clear reform agenda.

Thus, a distinguishing feature of Curriculum 2005 is its up front political agenda. Christie (1999) writes, 'Curriculum 2005 may be viewed as part of a suite of policies adopted by the post-apartheid government to restructure and transform the legacy of apartheid education and training' (p.297). The government under apartheid had used the curriculum as a means of consolidating power and control and as a mechanism for promoting the ideology of apartheid (Rasool, 1999). Curriculum 2005 becomes an important vehicle for change away from this and for restructuring South African society along democratic principles. This is captured in the introduction to the Curriculum 2005 policy document:

> The curriculum is at the heart of the education and training system. In the past the curriculum has perpetuated race, class, gender and ethnic divisions and has emphasised separateness, rather than common citizenship and nationhood. It is therefore imperative that the curriculum be restructured to reflect the values and principles of our new democratic society (NDE, 1997).

This is an ambitious statement, which has created expectation and hopes for what Curriculum 2005 will deliver. Curriculum 2005 thus aims to address both the challenges of the past and the challenges of the future. Due to the urgency in overcoming the legacy of apartheid, the intended pace of curriculum implementation was overly ambitious. However, since implementation on the ground could not keep up with the pace that government had planned, implementation became a very bumpy process with many promises and retractions of implementation dates.

The point about Curriculum 2005 being a change from the curriculum under apartheid is important, because the need for change is taken for granted in the South African context. Thus, while in some countries, curriculum change is met with resistance and a drive to maintain existing curricula, most South Africans and most teachers accept the need for a new curriculum. The report of the Review Committee on Curriculum 2005 showed there was overwhelming support for it (Chisolm *et al.*, 2000). The report, however, also showed the level of understanding

of outcomes-based education and Curriculum 2005 to be very low. So why the support for a new curriculum that is little understood? Simply, the support is due to its resonance with the broader political aims of the building of a new South Africa and the hopes that it might be able to contribute to the achievement of these aims.

It is important to place debate around Curriculum 2005 in the context of its rhetoric and its political aims. The effect of this on teacher voices and educators has been that to criticise Curriculum 2005 can place one in the precarious position of being labelled conservative and possibly anti-reform, a label which, with the baggage of the past, few educators want. Baxen & Soudien (1999) note that the South African Democratic Teacher's Union (SADTU) found themselves in a difficult position. They felt 'bound to the process' of OBE and Curriculum 2005 because of their alliance with the government. Thus the capacity for critique from teachers was constrained.

While there has been no public debate on the *need* for curriculum change and debate around Curriculum 2005 there has been some debate around the *nature* of the curriculum change. These debates are both at the level of policy (theory) and implementation and around the relationship between the two. Christie (1999) strongly questions the assumption that curriculum policy can be judged as 'good' without considering its implementation. She writes:

> These policy frameworks have given almost no attention to the context of implementation and how the new vision could be put in place in the profoundly unequal school contexts that apartheid left behind. This approach has implicitly assumed that the formulation of policy can be logically separated from its implementation (Christie, 1999, p.281).

Outcomes-based education has been at the core of the criticisms of Curriculum 2005. One of the first, hard hitting and publicised critiques of outcomes-based education came from Jonathan Jansen. His paper "Why Outcomes-based Education Will Fail: An Elaboration" first published in the press in 1997 and later in a book entitled *Changing Curriculum* (Jansen & Christie, 1999) outlines ten major reasons why OBE will impact negatively on South African schools.

These reasons are based on both policy and implementation issues and focus on: the complex and jargonised language used; the 'unproven' link between curriculum and economic change; flawed assumptions about South African classrooms and the teachers; specifying outcomes can be seen as anti-democratic; teachers' limited participation in the development of policy; the inherent focus on instrumentalism that side-steps important issues of values; the increased administrative burden on teachers; the trivialisation of curriculum content; the absence of a strong fiscal base for implementation; and the mismatch between final year external examinations and continuous assessment.

While many of Jansen's criticisms are technical and about the manner in which implementation is occurring in the South African context, his fourth criticism, that specifying outcomes can be seen as anti-democratic, attacks outcomes-based education from a philosophical and theoretical position. Other educators raise the same concern. Willis & Johnston (1998) write:

> Approaches to curriculum reform such as the one we consider here [OBE] are explicitly and unapologetically 'top-down', firstly in the sense that they begin by asking where we want to end up (outcomes), and secondly because they demand significant shifts in curriculum practice by centrally mandating the expected outcomes for all students (p.132).

Jansen (1999) goes on to conclude that, from a technical perspective, the prerequisites for changing curriculum are not in place. Furthermore, from a political perspective, OBE must be understood as a political symbol, which is necessary for the legitimacy of the new government.

Mohamed (1999) and Rasool (1999) respond to criticisms of OBE by arguing that critics do not offer alternative systems to OBE. They respond by asking what are the alternatives to OBE. Rasool (1999) argues that OBE should not be viewed simplistically as a 'solve all' for South Africa's educational and socio-economic ills and calls for *reconstructive* rather than *oppositional* critique. He concludes that rather than questioning the implementation of OBE one should look towards teacher support in order to enable it to happen. Unfortunately, reconstructive critique has also been largely absent from teacher critiques, possibly as a result of the presentation of the

curriculum to teachers as a *prescripted* initiative. As Baxen & Soudien (1999) have noted this results in low teacher participation that essentially involves the 'passing on' of OBE concepts.

However many of the issues raised by Jansen were identified as obstacles to implementation in the *Report of the Review Committee on Curriculum 2005* commissioned by the new Minister of Education, Kader Asmal[6], in February 2000. The report was prepared by an independent review committee, which was appointed to investigate, with regard to Curriculum 2005, its structure; strategies for strengthening its implementation; whether it should continue to be implemented in grades 4 and 8 in 2001; and teachers' levels of understanding of outcomes-based education. The report was prepared on the thorough review of existing research reports and papers, interviews with teachers, principals, managers, trainers, publishers and departmental officials as well as public submissions made by a range of individuals, organisations and institutions (Chisolm *et al.*, 2000).

The report states that the curriculum is both over designed and under specified. It suggests that there is: lack of alignment between curriculum and assessment policy; inadequate orientation, training and development of teachers; learning support materials that are variable in quality and availability; policy overload and limited transfer of learning into classrooms and shortages of personnel and resources to implement and support Curriculum 2005 (Chisolm *et al.*, 2000). Each of these points needs some unpacking.

The *over design* and *under specification* of the curriculum refers to the complex language and terminology used, the overcrowding caused by the inclusion of eight learning areas and the weakness of promoting sequence and progression (Chisolm *et al.*, 2000). The lack of alignment between curriculum and assessment policy is a crucial obstacle to implementation. In the review report this obstacle is explored in terms of the lack of clarity regarding assessment policy and practice and on the other hand a time issue with managing and administering assessment

[6] The first minister of Education under the new political dispensation in 1994 was Minister Bengu. It was under his ministry that Curriculum 2005 was developed and launched. His work as Minister of Education was heavily criticised in the press. This criticism largely focused on his lack of progress in bringing about fundamental changes in education (see Jansen, 1999b). When his term came to an end in 1999, Kader Asmal was appointed as the new Minister of Education. He soon commissioned a review of Curriculum 2005 with the intention of making the necessary changes to curriculum in order to make implementation more effective.

(Potenza, 2000). I, however, regard the lack of alignment between intended assessment policy (i.e. continuous assessment) and the practice of examinations and tests, which are still being used in many schools around the country under the instruction of district officials as a more critical obstacle in this respect. Furthermore, since the 'high stakes' assessment of the exit year of the Further Education and Training band (FET) is still examination based, continuous assessment has little credibility with teachers.

The point about inadequate orientation, training and development of teachers has been widely noted and Jansen (1999) makes the point that for many teachers it was simply non-existent. The report goes on to explain that, where orientation and training was implemented, the focus was on the language and terminology rather than on the substance of OBE. District trainers often did not understand the principles of OBE and therefore were not able to demonstrate OBE in their work with teachers. The data collected in this research supports this (see Chapter 7).

Curriculum 2005 has also been criticised by many (for example, Jansen, 1999; Taylor & Vinjevold, 1999) for its promotion of 'superficial' learning rather than grounded conceptual development. There has been the criticism that illustrative learning materials developed to demonstrate possible ways of integrating across learning areas have had the effect of 'watering down' important concepts in learning areas (Adler, Pournara & Graven, 2000). The shortage of high quality, learning support materials has been largely attributed to the unmanageable time frames of curriculum implementation (Potenza, 2000). The Review report (Chisolm *et al.*, 2000) argues that the policy overload and the shortage of necessary resources, including support personnel, is further preventing teachers from implementing the curriculum in their classrooms.

The changes in curriculum are paralleled by changes in the design of teacher roles for the purposes of teacher education. These changes are important in that they have implications for the development of teacher identities and teacher practices, both which are central to this study. I therefore expand on these roles briefly.

Teacher roles within the new education system

Under apartheid, teacher education was based on the philosophy of fundamental pedagogics and teachers were on the whole not granted professional autonomy nor provided the intellectual resources to critically asses their professional practice (Baxen & Soudien, 1999). With the changes to the broader education system, teacher education will inevitably need to be adapted in order to fall in line with the broader system. These changes however have been slow in being implemented and teacher training, at present, largely continues as it did in the past. That is, it is not premised on the principles of outcomes-based education, learner-centredness or continuous assessment.

The policy for the Norms and Standards for Education as contained in the February 2000 Government Gazette of the National Department of Education describes the roles, their associated set of applied competences (norms) and qualifications (standards) for the development of educators. According to the Department of Education (2000), applied competence is the overarching term for three interconnected kinds of competence, namely: practical competence, foundational competence and reflexive competence[7] and refers to the ability to integrate these competencies which constitute each of the seven educator roles. The seven roles that are outlined, by the National Department of Education (NDE, 2000) for educators are important because they define the new roles which teachers must adopt to be considered a professional within the new system of education. They are: learning mediator; interpreter and designer of learning programmes and materials; leader, administrator and manager; scholar, researcher and lifelong learner; community, citizenship and pastoral role; assessor, and learning area/ subject/ discipline/ phase specialist.

Each of these roles is significantly different to the roles adopted by teachers under the previous curriculum[8]. Since this study investigates teacher learning in relation to changing teacher roles

[7] Practical competence refers to the ability to consider a range of possibilities for action, make decisions about which action to follow and perform the action. Foundational competence refers to the ability to demonstrate understanding of the knowledge and thinking that underpins the action. Reflexive competence refers to the ability to integrate performances and decision making with understanding and to adapt to change, and to explain the reasons behind these adaptations. (NDE, 2000)

[8] The 'previous curriculum' refers, in general terms, to both the official policy and the dominant practices.

and identities, it is important that I briefly outline some of the main differences in the 'outgoing' roles of teachers and the future 'incoming' roles as designed within the new education system.

Learning mediator: In the previous curriculum the primary role of the teacher was to impart the knowledge and skills of various subjects to learners. 'Chalk and talk' was the dominant method used, in a wide range of schools, both privileged and disadvantaged (Graven, 1997; Vinjevold, 1999; Adler, 1994). The role of the teacher as learning mediator is very different from the role of teacher as the conveyor of knowledge and implies a change in beliefs about how learning takes place.

Interpreter and designer of learning programmes and materials: In the previous curriculum teachers were expected to 'deliver' the curriculum that was designed by the various departments of education. In order to do this most teachers relied on learning materials, mainly in the form of textbooks prescribed by the various provincial departments of education. Furthermore, pacing and sequencing was prescribed[9] in the form of a syllabus provided to teachers by districts. Adherence to the prescribed curriculum and syllabus would then be monitored through *ad hoc* visits to schools by district 'inspectors'. Thus, under the previous system, teachers had very little input or control over what was taught and were not prepared in their teacher education to make curricula decisions (Motala, Vally & Modiba, 1999).

This new role, on the other hand, requires teachers to 'design original learning programmes, identify the requirements for a specific context of learning and select and prepare suitable textual and visual resources for learning. The educator will also select, sequence and pace the learning in a manner sensitive to the differing needs of the subject/learning area and learners' (NDE, 2000, p.13). Taylor & Vinjevold[10] (1999) argue however that teachers lack the conceptual development necessary to implement OBE.

[9] Under apartheid there were various racially defined Departments of Education. Pacing, by schemes of work, was prescribed for all Departments except the White Departments of Education.

[10] Taylor & Vinjevold are the editors of a book which contains the synthesis of 35 research reports in South Africa, which were part of the President's Education Initiative. This project commissioned research in education in a wide range of South African schools.

Leader, administrator and manager: In the previous education system, schools were hierarchical institutions with a culture of top-down decision-making and passive acceptance of instructions by teachers (Mohamed, 1999). In this new role teachers are required to 'participate in school decision making structures' and will perform these 'in ways which are democratic, which support learners and colleagues, and which demonstrate responsiveness to changing circumstances and needs' (NDE, 2000, p.13).

Scholar, researcher and lifelong learner: Lifelong learning was not part of the discourse in the previous curriculum. Teacher studies at institutions were, for the most part, the culmination of organised learning unless institutionally based further studies were undertaken. In-service teacher development, in practice, was donor funded and usually run by the NGO[11] sector for a small portion of 'traditionally disadvantaged' South African schools. Education Department support for teachers was almost non-existent (Jansen, 1999).

Furthermore great inequalities existed in the quality and funding of teacher training within the various racially segregated departments of education. Research in education was almost exclusive to university staff or, in a few cases, teachers who enrolled for masters or doctoral studies. In this new role teachers 'will achieve ongoing personal, academic, occupational and professional growth through pursuing reflective study and research in their learning area, in broader professional and educational matters, and in other related fields' (NDE, 2000, p.13).

The importance of INSET is implicit in this new role. The National Department of Education is currently in the process of implementing a system by which all teachers must attend 80 hours of INSET per year.

Community, citizenship and pastoral role: In the previous curriculum the values teachers were required to pass on were those of Christian National Education and of the apartheid state. Christian National Education was designed by the National Party (the government under apartheid) to promote the values of a Christian and segregated society. In this new role, teachers

[11] NGO is the acronym for Non Government Organisation. NGOs played a very important role in education in the struggle against apartheid. The work done by these organisations were predominantly for under-privileged or previously disadvantaged communities and schools.

'will practise and promote a critical, committed and ethical attitude towards developing a sense of respect and responsibility towards others. The educator will uphold the constitution and promote democratic values and practices in schools and society… Furthermore, the educator will develop supportive relations with parents and other key persons and organisations based on a critical understanding of community and environmental development issues' (NDE, 2000, p.14).

Assessor: In the previous curriculum assessment was almost synonymous with tests, examinations, marks and percentages [12]. These marks enabled teachers to determine successes and failures and whether learners are to be promoted from one grade to the next. Curriculum 2005, on the other hand, introduces continuous assessment and insists that a range of assessment methods be used in order to feed back information to learners and parents in terms of the stated outcomes.

Learning area/subject/discipline/phase specialist: In the previous curriculum teachers needed to be primarily subject specialists. Their training required them to specialise in two teaching subjects and they were not expected to integrate across subjects. Working co-operatively with other teachers was not common practice. In Curriculum 2005, however, broader learning areas have replaced tightly bound subjects, teachers are required to integrate across learning areas and to work with other teachers in order to achieve this.

From the above we can see that major changes in teacher roles are demanded by the new curriculum. It should be noted, however, that while the new teacher roles provide more freedom and professionalism to teachers (through the flexibility incorporated in the description of these roles), they could also be experienced as disempowering for teachers. In the discourse used to explain teacher roles, terms such as 'appropriate', 'suitable' and 'effectively' are used without explanation or elaboration of what they might mean in practice. Without the necessary support for teachers, it is unlikely that teachers will be able to make use of the flexibility and increased professionalism incorporated in the roles.

[12] I am not including here the assessment methods of the foundation phase of schooling.

In summary:

Thus far, I have provided some description of the contentious curriculum change as part of a broader restructuring of post-apartheid South African society. I have argued that this curriculum change is being mapped onto a context of inequality in Education. It is in this context that this research, on teacher learning (about curriculum change), takes place.

I have argued that schooling is a major political exercise and the curriculum provides a window to viewing what the government and society believe learning should be about. The principles of equality, democracy and democratic participation, and eradicating racism and other forms of discrimination, are essential values that underpin the new curriculum. Furthermore, it is clear that schooling is viewed as an important vehicle to enable the change toward a democratic, equitable and non-racist South Africa.

The approach to learning which Curriculum 2005 adopts as a means to supporting change presents a mixture of OBE, competence–based, constructivist and learner-centred theories of learning. This reveals an underlying epistemology that knowledge cannot be isolated from its context and that knowledge is socially constructed. In resonance with the context of education change, teacher roles have been radically re-conceptualised. The educational change aims at empowerment of both teachers and learners. However, an analysis of the relationship between policy and practice reveals tensions and challenges to this empowerment. This is discussed in Chapter 2.

In the next chapter I provide an analysis of the current process of curriculum change focusing on mathematical changes. From this analysis I draw out various implications for teachers and for teacher learning in relation to adopting the new curriculum.

Part 3: Outline of the thesis

In this chapter I have provided the rationale and purpose of the study, and have set the context within which teacher learning is examined in this study.

In Chapter 2, I provide a thorough analysis of the current process of curriculum change in South Africa. The change is analysed from a Bernstinian perspective since this provides the tools for analysis and language for describing the mechanism through which education produces, and reproduces, social inequality. This is particularly important in the current transformatory context of a post-apartheid South Africa and supplements the data analysis that follows.

In Chapter 3, I provide a description and an analysis of the PLESME project that forms the empirical field for the study. I problematise and clarify the duality of my roles as both coordinator of the INSET and researcher. I describe the evolving design of the INSET (that forms the empirical field) in terms of various dilemmas that were confronted throughout the INSET, and I describe the activities of the INSET practice and various external factors that affected the practice.

In Chapter 4, I describe and explain the methodology used in the study and make a methodological contribution. It was necessary to draw on a wide range of research methods from several methodological traditions (for example, ethnography, field study and case-study) and to focus on a range of methodological issues concerning ethics, reliability, validity, generativity and generalisability. This study offers insight into an approach to researching INSET in which the researcher is simultaneously a central part of that INSET.

In Chapter 5, I provide the theoretical framework for the data analysis in relation to teacher learning that follows in Chapters 6 and 7. Incorporating Wenger's (1998) model into an analysis of teacher education programmes is relatively new. There is therefore an opening in the literature in terms of analysing INSET programmes for teachers from this perspective. The literature relating Lave & Wenger's (1991) work and more recently Wenger's (1998) work to mathematics education (and indeed mathematics teacher education) needs further development and critique. In this study I provide a detailed analysis of the work of Wenger (1998) and locate it within the broader field of social practice theory.

In Chapter 6, I provide an illustrative narrative vignette of one teacher's learning during his participation in the INSET programme, PLESME. This vignette clearly establishes that learning indeed occurred and from it the framework for the analysis of all teachers in the sample in Chapter 7 emerges.

In Chapter 7, I explore the nature of teacher learning in the PLESME community of practice. I explain that the mechanism for teacher learning is their participation in the PLESME community of practice and overlapping communities. This participation involves the complex intersection of the following components of learning: meaning, practice, identity, community and confidence. I elaborate on the role of confidence in relation to teachers becoming 'masters' of the practice of being professional mathematics teachers and construct its meaning from a socio-cultural perspective.

In Chapter 8, I draw out the main conclusions from the study, summarise the primary contributions of the study and provide some discussion of the implications of this study for the development of mathematical INSET in South Africa. I also highlight areas in need of further exploration.

Chapter 2: Analysis of the context of South African Curriculum Change

In Chapter 1, I described the changing education system in the context of South Africa's transition to a democratic and more equitable society. In this chapter I analyse the process of South African curriculum change, and focus on changes in the mathematics curriculum. In doing this I highlight the implications that the introduction of the new curriculum has for teacher education, teacher roles and for teachers learning about that curriculum change. This analysis is important because the study explores teachers learning *about* mathematics curriculum change. The chapter provides further contextual elaboration that locates the study and renders the stories of teachers and teaching that are told in the study more meaningful.

In Part 1, I draw on the work of Bernstein (1982, 1990, 1996) in order to analyse the primary changes introduced by Curriculum 2005. This analysis points to various implications and challenges inherent in the curriculum change process. In particular, I analyse the demands of curriculum change on teachers' professional identities.

In Part 2, I locate *mathematics* curriculum change within the broader context of curriculum change discussed in Part 1 and Chapter 1. In particular, I investigate the changes in the conceptualisation of mathematics as a learning area and the new demands on mathematics teacher roles.

It is important to point out that as I write this South Africa has developed a new National Curriculum Statement that is open to change and is currently being refined. When I worked with the teachers in this study this new National Curriculum Statement was not available and I worked with the Curriculum Statement as encompassed in Curriculum 2005. This said, the underlying principles of Curriculum 2005 discussed in this study (and as were incorporated in the INSET) remain central guiding principles to the process of curriculum reform. This process will be ongoing, and subject to revision, for some time to come.

Part 1: Using Bernstein to Analyse Curriculum Changes

In Chapter 1, I discussed the 'intended' curriculum, as stated in policy documents. In this Chapter, I analyse some of the contradictions and tensions that emerge in looking at curriculum as 'contextualised social process' (Cornbleth, 1990). Explanation of these contradictions and tensions

is essential to this study as they form the contextual background in which teacher learning takes place.

Why I have chosen to use Bernstein

The work of Basil Bernstein is widely noted for its usefulness in providing tools for analysis of contemporary changes in education (Harley & Parker 1999; Bernstein & Solomon 1999) and for providing a language, which describes the pedagogic mechanism through which education produces, and reproduces, social inequality (Lerman, 1998; Morgan, Tsatsaroni & Lerman, in press). Harley & Parker (1999) note that while Bernstein's work can be applied to many educational settings the scale and speed of change in South Africa makes the theory resonate evocatively.

For these reasons, I will draw on Bernstein's work as a framework for analysing contemporary curriculum change in South Africa. I will, in addition, return to the work of Bernstein in Chapter 7 since his concepts, particularly those of recontextualisation and identity, are also useful in analysing teacher learning in the context of INSET and broader curriculum change.

It should be noted that the work of Bernstein adds a particularly useful dimension to this study. His work resonates well within the context of the broader theoretical framework within which this study is working (discussed in Chapter 5). Briefly, most of this study draws on the work of social practice theory (Lave & Wenger, 1991; Wenger, 1998) drawing primarily on notions of communities of practice and notions of identity (Lave & Wenger, 1991; Wenger, 1998) as theoretical lenses for explaining, analysing and interpreting teacher learning. These works develop empirically, from particular cases of changing identity through participation in communities of practice, and do not yet offer a systematic, disciplined description of identity in broader terms. I believe that the work of Bernstein complements a more localised form of analysis of identity within communities with a broader concept of identity connected to macro structures of power and control. Bernstein (1996) writes:

> I have developed a model for showing how the distribution of power and principles of control translate into pedagogic codes and their modalities. I have also shown how these codes are acquired and so shape consciousness. In this way, a connection has been made between macro structures of power and control and the micro process of the formation of pedagogic consciousness (p.37).

Bernstein first introduced the concept of identity in 1971 (Bernstein & Solomon, 1999). This analysis did not focus on identity in terms of regulation and realisation in practice but rather on identity in terms of the 'construction of identity modalities and their change within an institutional level' (p.271). Thus Bernstein approaches identity from a broader systemic level, which of course impacts on enabling and constraining the emergence of localised individual teacher identities. It is in this respect that I see the work of Bernstein complementing the 'learning as becoming' perspective that I draw on to analyse teacher learning.

In this chapter I particularly draw on Bernstein's concepts of classification and framing, recognition and realisation rules, collection and integrated knowledge codes, competence and performance based pedagogic models, recontextualisation (Bernstein, 1982; Bernstein, 1996) and 'Projected Pedagogic Identities' (Bernstein & Solomon, 1999). These concepts provide useful conceptual tools with which to analyse contemporary curriculum change in South Africa.

Analysing contemporary curriculum change 'in general' in South Africa

I begin with the concepts of classification and framing since these concepts are central to all the other Bernstinian concepts that I use.

Classification refers to the degree of 'boundary strength' between areas of learning. However it does not simply refer to what is classified but also to the relations between these areas of learning.

> Classification refers to the nature of differentiation between contents. Where classification is strong, contents are well insulated from each other by strong boundaries. Where classification is weak, there is reduced insulation between contents, for the boundaries between contents are weak or blurred (Bernstein, 1982, p.159).

Framing, on the other hand, refers to the form of the context in which knowledge is transmitted[1] and received and refers to the 'specific pedagogical relationship between the teacher and the taught' (Bernstein, 1982, p.159). Bernstein (1982) writes,

> Strong framing entails reduced options; weak framing entails a range of options. Thus frame refers to the degree of control teacher and pupil possess over the selection, organisation,

[1] In educational terms, Bernstein's use of the terms 'transmitter' and 'acquirer' may seem pejorative. However, he uses them throughout various pedagogic models and they are merely sociological labels for descriptive purposes. They should therefore not be interpreted to imply transmission pedagogies.

> pacing and timing of the knowledge transmitted and received in the pedagogical relationship (p.159).

Curriculum 2005 clearly attempts to weaken classification through replacing previous discipline bound subjects with broader learning areas. For example, History, Geography, Democracy Education, Development Studies etc are combined into a single learning area called 'Human and Social Sciences'. The explicit attempt to weaken classification, also evidenced by the encouragement of integration between learning areas and with the broader environment within which learners work, indicates that Curriculum 2005 represents a move towards an integrated code. For example, Specific Outcome 8 in MLMMS is ‘analyse natural forms, cultural products and processes as representations of shape, space and time’ and Specific Outcome 6 in Natural Sciences is ‘demonstrate an understanding of the interaction between the natural sciences, technology and socio-economic development’ (NDE, 1997).

In Curriculum 2005 framing is weakened in all respects except the criteria of critical and specific outcomes (Harley and Parker, 1999). This is evidenced by the changing roles of teachers from deliverers of prescribed curricula to learning mediators who design and select learning materials, determine the sequence and pace of learning, use a variety of methods to assess learners, and make decisions based on democratic principles (NDE, 2000). The National Department of Education (1997) states that:

> Teaching will become a far more creative and innovative career. No longer will teachers and trainers just implement curricula designed by an education department. They will be able to implement many of their own programmes as long as they produce the necessary outcomes (p.29).

The intended changes in learner roles provide further evidence of a weakening of framing. Learners will now develop at their own pace and take more responsibility for their own learning and learners have a role to play in their assessment, in deciding when they are ready for assessment and in asking for re-assessment (NDE, 1997a). Furthermore parents and guardians have a role to play and take on more responsibility for the education of their children (NDE, 1997a).

Curriculum 2005: a move from a collection code towards an integrated code

Bernstein (1982) defines two broad types of curricula in terms of educational knowledge codes,

collection types and integrated types. A collection type exists where contents are clearly bounded and insulated, and juxtaposed to this, is the integrated type where contents are in open relation to one another. Thus by definition, collection types are strongly classified. Most traditional school curricula can be considered to be of the collection type in respect of the strong classification of contents as indicated by distinct subjects with specific time allocations and related status. In this situation there is a strong sense of membership for teachers to their subject and a related identity.

Reform curricula often attempt to weaken classification and Bernstein refers to such curricula as integrated. He points out that 'any organization of educational knowledge which involves a marked attempt to reduce the strength of classification is here called an integrated code' (Bernstein, 1982, p.160). Thus an integrated curriculum does not have to have *weak* classification but must show an attempt at *weakening* classification.

In this respect, it is useful to view strengths of classification along a continuum rather than simply as polar opposites of strong and weak classification. I have thus found it more useful to locate Curriculum 2005 (and thus current curriculum change in South Africa) in a process of movement between the poles, where the starting point, direction and distance of movement along the continuum are important. Similarly with framing, there are varying strengths along a continuum. Furthermore, there can be different aspects of a curriculum that will be differently placed along this continuum in terms of varying positions of classification and framing. For example, in Curriculum 2005, framing is weakened in terms of the increased teacher control over the selection, organisation, pacing and timing while the critical and specific outcomes to be met are not negotiable (NDE, 1997) and hence are tightly framed.

The current period of overlap between the outgoing curriculum and the incoming Curriculum 2005 and the inequality of implementation creates a very complex picture of curriculum as contextualised social process. It is however clear that the introduction of Curriculum 2005 indicates movement from a collection code towards an integrated code.

Curriculum 2005: a move from a performance model towards a competence model

In addition to the two types of educational knowledge codes (collection and integrated) Bernstein (1996) outlines two fundamental pedagogic models: *performance models* and *competence models*. Changes from one model to another can be traced by the identities projected by these models. In *Pedagogy, Symbolic Control and Identity*, Bernstein (1996) discusses these models in detail with

reference to common features such as categories of time, space and discourse, pedagogic orientation to assessment, pedagogic control, pedagogic text, and pedagogic autonomy. It is beyond the scope of this study to expand on these in detail. Briefly, I outline some of the main differences between these models as they shed light on key features of change entailed in the move from a performance model of education (the outgoing curriculum under apartheid) towards a competence based model (introduction of curriculum 2005).

According to Bernstein (1996), performance models serve primarily economic goals and are considered instrumental. These models emphasise specific outputs and texts the acquirer is expected to construct, and specialised skills necessary for the production of these. Acquirers have less control over selection, sequence and pace; pedagogic practices are explicitly regulated; time is explicitly punctuated; assessment aims to identify what learners have not acquired, that is, 'what is missing in the product' (p.60); and teacher professionalism is grounded in the pedagogic practice and grading procedures.

By contrast, in competence models acquirers have more control over selection, sequence, pace and over the pedagogic practices, which inhere in personalised forms. Time is not explicitly punctuated, (i.e. sequencing and pacing is more flexible), assessment emphasises what is *present* in the acquirer's product, and teacher professionalism inheres in the teacher's ability to interpret, or 'read' (p.61), products learners offer.

Bernstein (1996) goes on to identify three types of competence models: the liberal/progressive, the populist and the radical. These models are supported by different disciplines that provide legitimating ideologies of the projected model. These are, respectively: cognitive and developmental psychology, sociological approaches and critical social theory (Morgan, Tsatsaroni and Lerman, in press). All three models emphasise difference rather than deficit and share a common theme of consciousness. Bernstein (1996) writes:

> All competence models, despite oppositions, share a preoccupation with the development (liberal/progressive), the recognition (populist) and change (radical) of consciousness (p.68).

Bernstein (1996) describes how competence discourses became dominant in the pedagogic recontextualising field (PRF) in the late 1960s in Britain. Recontextualisation, in this sense, is the process of transforming a discourse. Two types of transformations occur when discourses are subject to recontextualisation. The first involves the transformation of discourses from a variety of

dominant discourses (e.g. political, educational) and various disciplines (e.g. psychology, sociology) into the construction of official discourse. The second transforms this new discourse into pedagogic practices (Morgan, Tsatsaroni & Lerman, in press). Thus the PRF can be divided into two sub fields: the official pedagogical recontextualising field (OPRF) and the unofficial pedagogical recontextualising field (UPRF) (Bernstein, 1996). The OPRF thus includes official curriculum documentation supplied by government or education departments, while the UPRF includes recontextualisation in, for example, the academic research, teacher support documents, teacher education programmes, etc. Pedagogical discourse is thus formed and used in contexts that are different from its substantive context (Morgan, Tsatsaroni & Lerman, in press).

In the sixties, in Britain, the weakening of performance positions in the PRF made space for competence positions to appear. In the sense that competence modes moved away from the concept of deficit (assessment in terms of what was absent rather than what was present), they were considered to be empowering. The three types of competence models were empowering in different respects: 'the liberal-progressive mode was the basis of cognitive empowerment, the populist mode was the basis of cultural empowerment, and the radical mode the basis for political empowerment' (Bernstein, 1996, p.71).

In South Africa, the introduction of Curriculum 2005 indicates a clear move away from performance-based modes towards a more competence-based mode (see Chapter 1). I would argue that Curriculum 2005 presents a combination of discourses from all three of the competence modes identified by Bernstein (1996). It combines the liberal/progressive aims of cognitive empowerment (introduction of learner-centredness), populist aims of cultural empowerment (redress apartheid issues) and the radical mode aims of political empowerment (enable democratic citizenship). In common with all three models, Curriculum 2005 has at its core the aim of teacher and learner empowerment (discussed in Chapter 1).

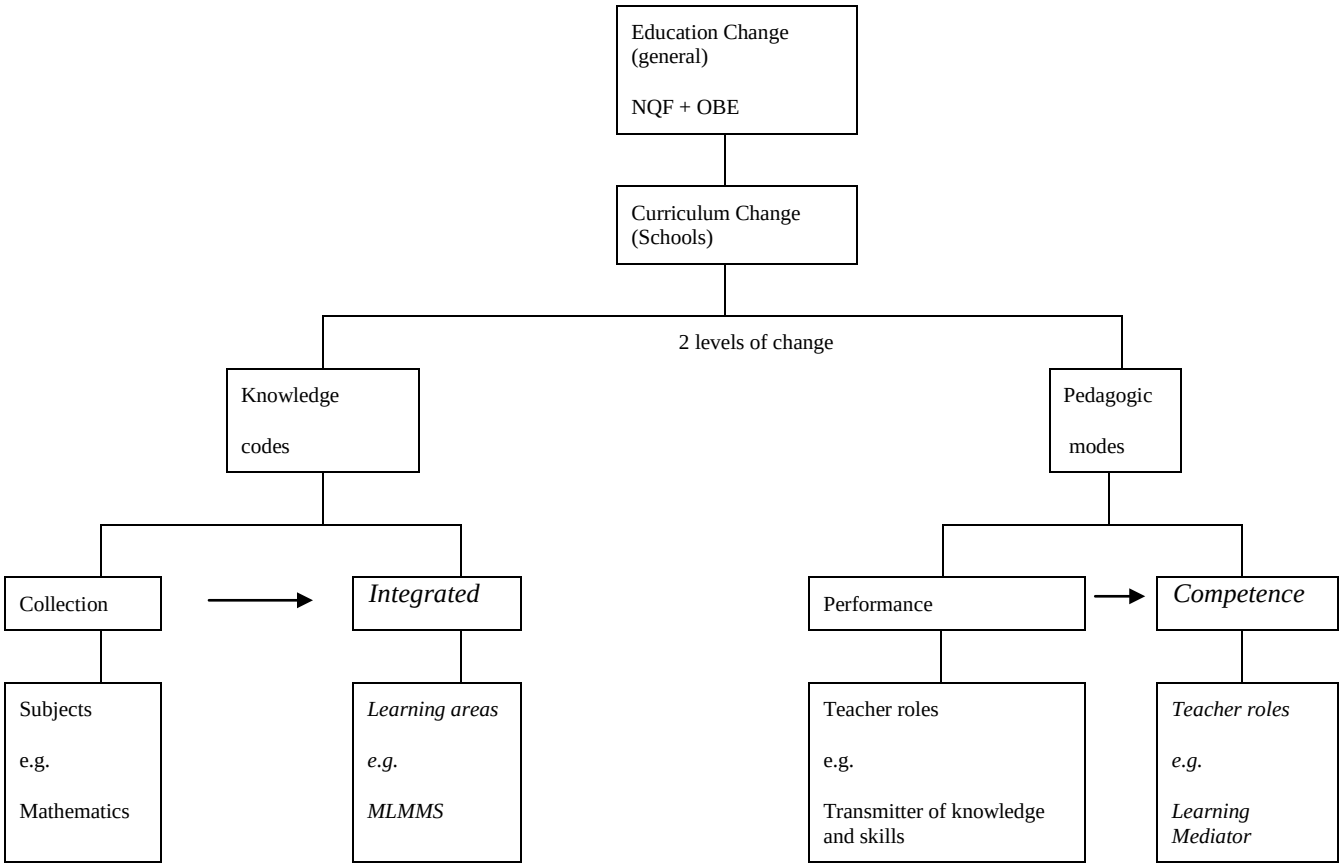
Similar to the process in Britain, the disappointment with traditional curricula based on performance models and their continued production and reproduction of inequality, created space for competence positions to emerge in the PRF. However, within the context of a post-apartheid South Africa, the space created was far greater than in the case of Britain. With the abolition of apartheid and the introduction of a new democratically elected government, radical political and social restructuring was taking place. Within this context of restructuring, the new government was expected to implement an education system that would reduce inequality and enable empowerment,

and hence space was created for the emergence of competence-based discourses in the OPRF and the UPRF.

There are however some theoretical tensions inherent in locating OBE, a foundation of Curriculum 2005, within a competence model. Where do pre-defined outcomes fit within a competence model of education? Since an outcomes-based approach involves setting benchmarks, it inevitably incorporates the concept of deficit, which is contradictory to competence models (Harley & Parker, 1999). Thus it should be noted that while Curriculum 2005 demonstrates a clear move away from a performance-based model towards a competence-based model, some theoretical tensions exist in relation to OBE.

In sum, in Bernstein's terms, Curriculum 2005 presents a move from a collection type towards an integrated type knowledge code *and* a move from a performance based model towards a competence based pedagogical model. Embedded in these changes is a weakening of both classification and framing. The following diagram provides a summary of these movements.

Figure 2.1: A diagrammatic summary of Curriculum Change in South Africa



What are the effects of these curriculum changes?

The changes described above are important because they effect the construction of identities (and related discourses, social relations and power). Bernstein & Solomon (1999) note that 'pedagogic modalities, generated in the recontextualising arena, attempt to shape and distribute forms of consciousness, identity and desire' (p.270). Furthermore, Bernstein (1996) notes that changes in models will also have an effect on education costs (*economy*), both in terms of time and finances. Thus challenges arise from curriculum change and further tensions will arise in attempts to meet these challenges. It is important to unpack these challenges and tensions, and the relationships between them. It is to this that I now turn.

I begin with the challenge arising from increased education costs resulting from a move towards a competence-based model of education. Bernstein (1996) notes that the costs of competence models are likely to be higher than performance models due to increased 'hidden costs'. These hidden costs are in terms of time needed for teachers to design resources, evaluate learners, hold discussions

with colleagues and parents etc., and also in terms of teacher development because of the nature of the theoretical base underlying such a model. Curriculum 2005 has clearly been hampered by these increased costs, which have put pressure on the limited finances available for education. Bernstein (1996) notes that ‘these hidden costs are rarely explicitly recognized and built into budgets, but charged to the individual commitments of teachers’ (p.63). This has certainly been the case in South Africa, and with a result, implementation of Curriculum 2005 has been repeatedly postponed and where implemented, implementation has been uneven and hampered by limited, not to mention the unequal distribution of, resources (Jansen, 1999; Christie, 1999).

Charging these hidden costs to the individual commitments of teachers is particularly problematic considering the widespread low morale of teachers. Motlala, Vally & Modiba (2000) write:

> The unintended consequence of teacher rationalisation, rightsizing and redeployment was a limited redistribution of educator personnel, the departure of many committed educators, and insecurity, lack of enthusiasm and low morale amongst those who chose to continue teaching (p.17).

Bernstein’s concept of identity illuminates the enormous challenge for South African teachers inherent in the revised curriculum and revised teacher roles as developed in the OPRF. The concept of identity is useful in identifying challenges embedded in both changes in knowledge codes and changes in pedagogic models. I will examine these challenges in terms of the relation between policy and implementation. It should however be noted that, due to the profoundly unequal education contexts that apartheid left behind, recontextualisation from the OPRF to the UPRF will not be uniform. Challenges and tensions will differ depending on the context of implementation.

I begin with the challenges resulting from the changes in knowledge codes. It has already been argued that Curriculum 2005 indicates a move away from a collection type code towards an integrated type and therefore the strengths of classification and framing are weakened. Since classification ‘provides us with our voice and the means of its recognition' and framing 'is the means of acquiring the legitimate message’ (Bernstein, 1996, p.26), the recognition and realisation rules within the integrated code will be different from those in a collection code. Teachers will need to acquire new recognition rules, ‘by means of which individuals are able to recognize the speciality of the context they are in’ (p.31), and new realisation rules, by means of which individuals are able to produce the legitimate text.

Harley & Parker (1999) note however that shifts from strongly classified collection codes to more weakly classified collection codes can create ambiguity that leaves the recognition rules elusive. They write that 'Curriculum 2005 could be creating a new set of recognition rules unfamiliar to both teachers and learners' (p.92). The elusiveness of such rules will be a serious obstacle to curriculum change. Furthermore these changes in recognition and realisation rules, which are implicit in the move from subject specialist to generic educator, clearly increase the costs involved in teacher education, especially with respect to time, as has already been mentioned above.

If teachers do not have access to necessary resources, which enable them to identify the recognition rules of the new practices, they are constrained from developing identities that conform to the official pedagogic discourse. It should also be noted that acquiring recognition rules is not sufficient for implementing new practices. Teacher support is necessary for the acquisition of realisation rules to assist teachers in producing the necessary discourse and texts needed for implementing new practices. Unfortunately, as noted above, resources for teacher support are extremely limited in South Africa at present.

However, when changes in codes are not paralleled by changes in related features of practice, such as organisation of time, it might become impossible, even when recognition rules are acquired and teachers are able to produce the appropriate text under favourable conditions, to achieve realisation in practice. For example, if in schools time continues to be punctuated in 35-minute periods for different learning areas, and if assessment continues to be subject-based and if time is not made available for teachers to work collaboratively and hold meetings, integration between learning areas is unlikely to be realised[2].

These changes in codes will further affect the subject loyalties of teachers, in the sense that previous loyalties to a subject must now be subverted and replaced with a more generic loyalty as evidenced by the National Department of Education's promotion of the 'generic educator' (NDE, 2000). The relative status of a subject, and therefore teachers' related status and identity, could now radically change. For example, in Curriculum 2005, the learning area of mathematics was awarded equal status to other learning areas in terms of time allocated to it. This is a change from the previous status of mathematics, which was awarded a greater amount of time and importance relative to other subjects. This change has however been contested by the Review Committee (see

[2] So far timetables continue as they did in the past with 35-minute periods being the norm. Furthermore assessment at Grade 12-level continues to be subject bound militating against integration at lower levels of schooling.

Chisolm *et al.*, 2000) and many provinces have already reverted to increased time allocation for mathematics and languages.

Challenges are also implicit in the change of pedagogic mode. That is, from a performance mode towards a competence mode. The previous curriculum under apartheid clearly adopted a 'technocratic' (Cornbleth, 1990) approach to education. That is, there was a conceptual separation between policy and implementation, curriculum was described as 'value neutral' and problems with curriculum were ascribed to poorly prepared teachers rather than policy. Teacher identities, up to now, have therefore developed within the technocratic and performance-based approach of the previous education system. Harley & Parker (1999) note,

> One aspect of South Africa's difficulties in implementing Curriculum 2005 lies in the attempt to graft a legalistic social framework and curriculum of organic solidarity onto a corps of teachers whose identities and roles were forged in the apartheid mills of mechanical solidarity (p.193).

Since critical thinking (an important aspect of a radical competence model) is of primary importance in the new curriculum, debate and open reflection on curriculum is invited from teachers and educators (see Asmal, 2000). However, teacher voices remain largely absent from the debates around curriculum and input into curriculum processes is extremely limited (See Jansen, 1999; Christie, 1999). A logical explanation for this is that the new curriculum is precisely that, 'new'. It is foreign and unfamiliar to teachers, and it is a radical shift away from previous curriculum philosophies and therefore away from teacher experiences.

Confronted with the difficult language of OBE it is almost impossible for teachers to engage with curriculum debate since they do not have the necessary 'tools' to enter into the unfamiliar discourses and practices. Furthermore the varying contexts, within which curriculum 2005 must be implemented, create further tensions and challenges. A powerful criticism from many educators has been that the teachers most likely to succeed at implementing the new curriculum and input into its development process are those from privileged schools with enabling resources. Jansen (1999) writes:

> A small elite of teachers, often expert and white, have driven the Learning Area Committees and other structures in which OBE has developed. The sad reality is that the overwhelming majority of teachers simply do not have access to information on OBE, or understand OBE in

> instances where such information may be available. In other words, there is not a process, systematic and ongoing, in which teachers are allowed to conceptualise and make sense of OBE and curriculum policy. In a cruel twist of history, teachers continue to be defined as 'implementers' and even in this marginal role, official support is uneven, fragmented and, for many teachers, simply non-existent (p.151).

Christie (1999) points out that:

> The sophistication of the policies brings the unintended effect that they are likely to be of most benefit to those communities and schools that have resources to take advantage of the opportunities they offer. For under-resourced communities and schools, these policies may produce the opposite effect, acting as extra burdens rather than opportunities for improvement (p. 282).

Thus ironically, the aims of Curriculum 2005 to reduce racial division and promote equity in education will not necessarily be met and the gap between the 'haves' and the 'have nots' might increase.

Many educators have further argued that, Curriculum 2005 does not sufficiently acknowledge the extreme inequalities created under apartheid. Christie (1999) writes:

> These policy frameworks have given almost no attention to the context of implementation and how the new vision could be put in place in the profoundly unequal school contexts that apartheid left behind. This approach has implicitly assumed that the formulation of policy can be logically separated from its implementation (p.281).

Baxen & Soudien (1999) support this point:

> What is being foreclosed in the consensual language of OBE are the more complex manifestations of difference and inequality, therefore, of equality and equity. Omitted in the discourse of OBE is a deliberate awareness of the very divides and fractures which have specified the public face of South Africa (p.141).

The above quotes seem to indicate that it is unlikely that all teachers will similarly acquire the recognition and realisation rules necessary for implementing the new curriculum. Bernstein (1996) refers to research conducted by Holland (1982), which shows how children from different social

backgrounds use different principles of classification. The study demonstrates how children from working class backgrounds selected non-specialized recognition rules in contrast to middle-class children who gave primacy to specialised recognition rules in order to classify.

Cooper & Dunne (1998, 2000) similarly demonstrate how working class children did not acquire the specialised recognition rules, necessary for success at new forms of national mathematical assessment items. An important question to ask in the South African context, where inequality in social and educational backgrounds are extreme, is whether the majority of teachers[3] will be disadvantaged by their backgrounds and constrained from acquiring the recognition rules of the new practice, thereby exacerbating current inequalities.

In this context increased teacher empowerment becomes difficult. In the absence of support, teachers are denied important opportunities necessary to enable them to explore new identities in relation to these new roles and philosophies, and to acquire the related new recognition and realisation rules. How can teachers begin to benefit from increased 'empowerment' when the new curriculum and its philosophies and methodologies are foreign? Thought needs to go into support for teachers in order to enable a voice and the necessary critical participation of teachers in the curriculum process. Motala, Vally & Modiba (1999) point out that a challenge lies in the balance that will have to be found between 'providing support materials to teachers and enabling them to be critical, independent curriculum developers' (p.20).

The NDE's Curriculum 2005 document (1997) and the Norms and Standards document (2000) can be seen as constituents of a 'projected official pedagogic identity' (Bernstein & Solomon, 1999, p.271). This official identity should however be distinguished from teacher identities, which emerge, enabled or constrained, within the context of this projected identity. Wenger (1998) makes the point that while roles can be designed, identities cannot. There are several important questions to ask in this respect. What is the nature of the relationship between teacher roles (as encompassed in the Official Projected Pedagogic Identity) and the development of teacher identities? Which identities are available to teachers in the context of the Official Projected Identity? What identities are constrained within the context of the Official Projected Identity? How are identities enabled or constrained in curriculum processes of implementation (for example in, dissemination of illustrative

[3] The vast majority of South African teachers are 'African'. In this respect, it can be argued that most South African teachers have come from backgrounds disadvantaged by the apartheid system, politically, economically and educationally.

learning programmes, departmental support, school reorganisation etc.). These questions will be addressed in Chapter 7.

Related to the concept of identity, important changes in social relations and control are inherent in changes in education modes (and the resultant weakening of classification and framing). With knowledge being more weakly classified, power in social relations will change. Thus the social relations between mathematics teachers and other teachers will be affected. Harley and Parker, (1999) write:

> With knowledge weakly classified, so the power embedded in social relationships shifts from the vertical to the horizontal. In the vertical plane, the loyalties of pupils are to subject teacher, and from subject teacher to subject head, and so on. On a horizontal plane, learners have a stronger relationship with one another in co-operative learning, and teachers with one another as they attempt to integrate knowledge. Teachers and learners also 'work together' to achieve a common goal: achievement of the outcomes. This implies a profound shift in personal allegiances and loyalties from the positional emphasis of a mechanical solidarity and strongly classified curriculum to the interpersonal, weakly classified emphasis of an organic solidarity (pp.191-192).

Bernstein (1996) warns that ‘the principle of classification comes to have the force of the natural order and the identities that it constructs are taken as real, as authentic, as integral, as the source of integrity’ (p.21). Other indicators of challenges to social relationships and related power and control are evident in the new curriculum. For example: the relatively recent abolition of corporal punishment in schools; the role of teacher as decision maker within schools; the role of the teacher as learning mediator rather than a transmitter of knowledge; and the increased accountability of teachers to parents and community. All these are indicators that control is shifting from ‘positional’ forms towards more ‘personalised’ forms and from the vertical plane to the horizontal plane.

In summary:

I have used the work of Bernstein to assist in identifying possible implications and challenges inherent in the change in education models (from collection to integrated and performance to competence) as indicated by the introduction of Curriculum 2005. I have argued that while the weakening of classification and framing in Curriculum 2005 (which is inherent in the move towards integrated codes and competence based models of education) can be seen as ‘empowering’ and

resonate with the political aims, in practice this weakening can be 'disempowering.'

I have argued that 'empowerment' is unlikely for the majority of teachers unless they are supported with necessary resources to enable them to construct new identities. These identities will need to resonate with the newly designed roles and to acquire the related recognition and realisation rules for the new forms of practice. Furthermore, if the inequalities produced under apartheid are not confronted, inequality could be exacerbated by the changes inherent in Curriculum 2005. The meanings and interpretations that teachers assign to the curriculum change process will therefore differ and while new education roles are designed it is not possible to design the identities of teachers, which will form in uneven ways during the change process.

Thus, I concur with Harley & Parker (1999) that this implies that teacher development in this context of change is far more complex than simply retraining teachers and that ways must be found for teachers to conceptualise and construct their new professional identities. They conclude:

> To implement OBE and the NQF, teachers may well need first to shift their own identities, their understanding of who they are and how they relate to others (p.197).

This study explores teacher learning about contentious new curriculum policies during an uneven and problematic implementation process. The challenges inherent in the implementation of new policies will impact on the nature of teacher learning and especially on the development of teacher identities in relation to the new roles they are expected to adopt. In Chapter 6 and Chapter 7 the implications of the inherent tensions and challenges of current curriculum change (especially as relates to the move from a performance-based curriculum towards the competence-based Curriculum 2005) are illustrated through textured vignettes and quotes of the teachers who participated in this study.

In the next section I focus my analysis on the changes in mathematics inherent in Curriculum 2005 and highlight related challenges and tensions.

Part 2: A focus on changes in mathematics and the implications for mathematics teacher learning

The primary focus of this study is explaining teacher learning. This learning is however about becoming professionalised *mathematics* teachers able to adopt (and critically evaluate) new

mathematics practices inherent in Curriculum 2005. It is therefore important to identify, within the broader curricula changes, changes in the mathematics curriculum. My purpose here is to describe and analyse changes in official mathematics documentation and to relate these to the implications for mathematics teacher learning in this study.

The first change to note in relation to the new mathematics curriculum is the replacement of the subject *Mathematics* with the Learning Area of *Mathematical Literacy, Mathematics and Mathematical Sciences* (MLMMS). The name has its origins in the National Learning Area Committee (LAC) Task Team for Mathematics. LACs were established for each of the eight learning areas. Their brief was to write a rationale and the specific outcomes for their learning area (Chisolm *et al*., 2000). Professor Laridon [4], of Mathematics Education at the University of the Witwatersrand, and a member of this LAC, explained the intentions behind the long name. He explained that *Mathematical Literacy* indicates the inclusion of numeracy and spatial literacy. *Mathematics* indicates the inclusion of 'pure' mathematics as distinct from mathematics for applied purposes, and *Mathematical Sciences* indicates the inclusion of applied mathematics such as statistics, architecture, financial mathematics etc. as well as the importance of developing mathematical skills for critical democratic citizenship and use in everyday life.

While the change from subjects to learning areas indicates a weakening of classification in the curriculum in general, the learning area MLMMS remains relatively insulated in comparison with other learning areas. While the new name indicates a broadening of the predecessor subject *Mathematics,* the contents of MLMMS remain similar and while integration between these contents is encouraged they maintain a degree of insulation between one another. For example, the MLMMS Draft Progress Map (1999) of the Gauteng Department of Education (GDE) and the Gauteng Institute for Curriculum Development (GICD) identifies four strands within MLMMS. These are, Number and Algebra, Shape and Space, Measurement, and Data.

In contrast, subjects such as History and Geography have been radically changed and are combined into the learning area of *Human and Social Sciences.* This learning area includes Geography, History, Democracy Education, Development Studies, Environment Studies, World Ethics & Belief systems, Utility and Social Services (Tiley & Goldstein, 1997). Appendix 1 provides a rough summary of the contents of the eight learning areas.

[4] This information was obtained in a discussion (December 2000) with Professor Paul Laridon who served on the

While the weakening in the strength of classification from Mathematics to MLMMS appears to be less than that of other learning areas, changes in the philosophy of mathematics and mathematics education are more radical. These philosophical changes relate to the approach to mathematics teaching, the nature and contents of mathematics and the role of mathematics education. Below, I deal with each of these changes briefly.

The approach to mathematics teaching and learning

The recognition of the social and cultural influences on mathematics learning and the construction of mathematical knowledge have been largely informed by developments in Psychology and Social Anthropology. Recent cognitive and anthropological research in the field of mathematics learning (e.g. Carraher, Carraher & Schliemann, 1985; Lave 1988; Saxe, 1990; Human, 1990) provide support for the thesis that:

1. Mathematics learning is a human creation evolving within social and cultural contexts
2. Learners actively construct mathematical knowledge through interaction with the social and cultural environment.

These emphases are inscribed within the Curriculum 2005 definition for MLMMS. This definition informs all of mathematics teaching from Grade R (reception year) up to Grade 12[5]. The definition of mathematics as outlined in the National Department of Education's *Curriculum 2005 Policy Document* (1997) is:

> Mathematics is the construction of knowledge that deals with qualitative and quantitative relationships of space and time. It is a human activity that deals with patterns, problem-solving, logical thinking etc., in an attempt to understand the world and make use of that understanding. This understanding is expressed, developed and contested through language, symbols and social interaction (p.2).

In pedagogical terms the new mathematics curriculum requires teachers to adopt more socio-constructivist approaches to mathematics teaching and learning rather than simply 'passing on' to learners pre-discovered mathematics and algorithms. The socio-constructivist approach to

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Mathematics Learning Area Committee in 1997.

[5] The GET band is broken up into a reception year and three phases. Grade R is the reception year. Grades 1-3 make up the foundation phase, grades 4-6 make up the intermediate phase, grades 7–9 make up the senior phase. Grades 10-12 are part of the further education and training band (FET) which is currently in the process of being redesigned.

mathematics teaching was very influential in primary schools in South Africa in the late 1980s and early 1990s[6].

Furthermore the new mathematics curriculum requires teachers to interpret the seven roles for educators (discussed in Chapter 1) within the context of MLMMS. For example, MLMMS teachers will need to take on the role of becoming a MLMMS learning mediator, interpreter and designer of MLMMS learning programmes and materials; lifelong learners in the field of MLMMS etc. Within these roles teachers should use a range of learner-centred and co-operative methodologies in order to facilitate conceptual and relational mathematical understanding rather than rote or procedural mathematical knowledge. In accordance with Curriculum 2005, assessment in MLMMS will need to be continuous.

The nature and contents of mathematics

MLMMS encompasses a radical shift in philosophy as to the nature of mathematics from its predecessor the subject *Mathematics*. It indicates a shift away from an 'absolutist paradigm', which views mathematics as a body of infallible objective truth which has little to do with the affairs of humanity (Ernest, 1991). In MLMMS, Mathematics is by definition a 'human activity' (NDE, 1997). The *Rationale* to MLMMS further states that mathematics should empower learners to understand the contested nature of mathematical knowledge (NDE, 1997).

In this new learning area the curriculum shifts its focus from reproducing and mastering abstract mathematical skills and algorithms to constructing mathematical meaning in order to understand the world and make use of that understanding. Mathematical learning is to be relational, shifting from its current production of inert knowledge, to knowledge that is flexible, transferable and integrated with everyday life and other learning areas (Adler, Pournara & Graven, 2000).

The specific outcomes for MLMMS as defined by the NDE (1997) are:

1. Demonstrate understanding about ways of working with numbers.
2. Manipulate number patterns in different ways.
3. Demonstrate understanding of the historical development of mathematics in various social

[6] A research project in the Western Cape (Human, 1990) investigated the effectiveness of a socio-constructivist approach that was implemented in many schools throughout the Western Cape. Various learner materials were developed in order to support this work and these are still used in many schools.

and cultural contexts.

4. Critically analyse how mathematical relationships are used in social, political and economic relations.
5. Measure with competence and confidence in a variety of ways.
6. Use data from various contexts to make informed judgements.
7. Describe and represent experiences with shape, space, time and motion, using all available senses.
8. Analyse natural forms, cultural products and processes as representations of shape, space and time.
9. Use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes.
10. Use various logical processes to formulate, test and justify conjectures (p.3).

Specific Outcomes 3, 4 and 8 indicate a clear move away from the absolutist philosophy of mathematics. Mathematics is related to historical, social, political and cultural contexts. The outcomes also indicate changes in the contents as to what constitutes appropriate mathematical areas of study for school mathematics. The emphases on content areas such as *Data* and *Shape and Space* (as distinct from Euclidean geometry) are new to the learning area.

The role of mathematics education

MLMMS is now charged with the important role of helping to build a new democratic, equitable, non-racist, non-sexist South Africa. Thus, in resonance with the political aims of preparing learners for participation in a democratic society, the curriculum places a significant emphasis on the contextualisation of mathematics, socially, politically, economically and historically. It also places a significant emphasis on particular mathematical processes such as mathematics communication, interpretation and justification. This is evidenced by several of the specific outcomes that have embedded in them ways of working mathematically that are necessary for preparing learners for critical democratic citizenship. For example, specific outcome number four states, learners can 'critically analyse how mathematical relationships are used in social, political and economic relations'.

Political aims also emerge clearly within the *Rationale* given for MLMMS (NDE, 1997):

> These domains [MLMMS] provide powerful numeric, spatial, temporal, symbolic, communicative and other conceptual tools, skills knowledge, attitudes and values to:
>
> - analyse;
> - make and justify critical decisions; and
> - take transformative action,
>
> thereby empowering people to:
>
> - work towards the reconstruction and development of South African society;
> - develop equal opportunities and choice;
> - contribute towards the widest development of the society's cultures;
> - participate in their communities and in the South African society as a whole in a democratic, non-racist and non-sexist manner;
> - act responsibly in protecting the total environment;
> - interact in a rapidly-changing technological and global context;
> - derive pleasure and satisfaction through the pursuit of rigour, elegance and the analysis of patterns and relationships;
> - understand the contested nature of mathematical knowledge; and
> - engage with political organisational systems and socio-economic relations (p.2).

This is clearly a challenging role for MLMMS considering its highly classified predecessor *Mathematics*.

In sum, MLMMS represents major philosophical shifts in three areas, namely, the approach to mathematics teaching and learning, the nature and contents of mathematics, and the role of mathematics education. In light of the vast amount of literature which stresses the long term nature and difficulty in bringing about changes in teacher and learner conceptions of mathematics (for example, Becker & Pence, 1996; Fennema *et al.*, 1996; Thompson, 1992), it is important that the enormity of the philosophical shifts demanded of both teachers and learners is not underestimated.

As noted in Chapter 1, these changes in mathematics education did not originate in Curriculum 2005. The transformation agendas of movements such as People's Education and the NECC are particularly clear in MLMMS. Changes in the political dispensation opened the door for 'progressive' mathematics educators from the People's Education movement, the National

Education Co-ordinating Committee, non-government organisations (NGOs), universities and independent schools to become involved in the curriculum development process. The invitation to these educators to be part of the LACs provided the opportunity to crystalise their 'progressive' ideas into official documentation.

In Bernstein's terms the crystilisation of these ideas into policy reflects a mixture of the liberal/progressive, populist and radical competence models. Socio-constructivist influences in mathematics education could be seen as the key to cognitive empowerment. The people's education movement and other mathematics NGOs focused on using mathematics as a vehicle towards cultural and political empowerment. This is evidenced by the popularity of various ethnomathematics ideas and the importance of mathematics for critical democratic citizenship. Thus MLMMS combines all three of the competence models in its attempt to enable cognitive, cultural and political empowerment.

While many of changes demanded by MLMMS reflect the developments in progressive mathematics curricula around the world, a specificity of Curriculum 2005 is that it combines a wide range of 'progressive' mathematics education philosophies into a national curriculum. In addition, unlike most national curricula throughout the world, Curriculum 2005 repeatedly stresses the socio-political and cultural aspects of mathematics education. Furthermore the implementation of 'progressive' mathematics curricula differs depending on the context of implementation. While some of the features of MLMMS have been implemented in curricula in other countries there are several factors, particular to the South African context, that need more detailed consideration.

These factors include: the wider political changes taking place; the legacy of apartheid; the relatively weak knowledge base of many teachers, and the range of difficult working conditions in many schools (discussed in Chapter 1). These factors clearly influence South African teachers of all learning areas. The effects of these factors are however in many cases exacerbated in MLMMS. For example, the legacy of apartheid has left a particular shortage of qualified black[7] mathematics teachers resulting in particularly large mathematics classes (sometimes in excess of 60 learners), many schools not offering mathematics in the FET (Grades 10-12) phase and in many cases untrained mathematics teachers having to teach mathematics. The effect of this is poor performance, particularly in mathematics, and the distribution of this failure is heavily skewed in

[7] In South Africa, black has been used to refer to African, coloured and Asian people, as well as to refer only to 'people of African origin'. In this study I use black to refer to people of African origin.

racial terms (Adler, 2001).

This poor performance is evidenced by the results in the 1997 Third International Mathematics and Science Study (TIMSS) where South Africa scored worst out of the 42 participating countries (Howie, 1997). While such international comparative assessments should be interpreted with caution (Keitel & Kilpatrick, 1999) and considered in light of a range of factors[8], statistics of local national assessments similarly reflect particularly poor performance in mathematics. Of every 10 000 black children who start school, only one will pass with a matric exemption[9] in Mathematics and Science (Kramer, 1990). Gerdes (1986) points out that mathematics is the most effective educational filter and clearly this 'filter' metaphor is particularly applicable to South Africa.

In the *Submission by the Mathematics Education Community to the Council of Education Ministers* (Adler, Brombacher & Shan, 2000) four key dimensions of the 'crisis in Mathematics Education' are noted. These include:

1. Particularly poor performance in Mathematics. At matric level, mathematics performance is way below that of any other subject both in terms of participation and success.
2. Most teachers have a seriously impoverished understanding of mathematics.
3. The widespread view that only a few can succeed in Mathematics.
4. The under utilisation of expertise and experience of the mathematics NGO sector.

These dimensions illustrate particular difficulties and challenges for mathematics education. The case of many teachers of mathematics not having mathematics training creates an interesting area for research when one considers Bernstein's concept of identity and teacher subject loyalties discussed in Part 1. What does it mean for non-trained mathematics teacher to develop an identity as a practising mathematics teacher? While it is beyond the scope of this study to explore this in detail, some anecdotal evidence is revealing. In a discussion with Barry, a PLESME teacher, he insisted that he was not a mathematics teacher despite the fact that he had taught it, with success, for more than twenty years. When asked why he did not think he was one he insisted that he was not trained as one and did not know 'high level mathematics' [Journal, October 1999].

[8] Research conducted by the HSRC through student questionnaires indicated that only twenty-one percent of the South African learners wrote the achievement tests in their home language (Howie, 1997).

[9] Matric examinations are written in the twelfth and final year of schooling and exemption is a crucial determinant for

This raises questions as to the definition of a mathematics teacher. Should such a definition be according to training or knowledge or practice or experience or official position? In the context of South Africa's shortage of qualified mathematics teachers it becomes important to explore models of INSET which will support unqualified teachers of mathematics to develop identities as mathematics teachers that enable them to perform the various roles specifically demanded by MLMMS.

Another challenge, particularly difficult for mathematics teachers, involves integration. Chisolm *et al.* (2000) argue that the designers of Curriculum 2005, in an attempt to counteract the rigidities of the old subject-based curriculum, have given too much attention to integration at the expense of conceptual coherence. The report sites this as a particular problem for fields of knowledge where attention to progression is structurally important, namely, in languages, sciences and Mathematics. These learning areas have an extended knowledge base, in that they extend up into the FET and higher education bands. They argue that, 'the result is a weaker grasp of the central skills and concepts of mathematics, which in turn jeopardise higher skill acquisition' (p.35).

Furthermore integration creates an added burden for teachers in terms of knowledge demands and time demands. For example, integration within mathematics requires of teachers a deeper understanding of mathematics, because it requires teachers to draw out connections between contents and processes. In light of the many under-qualified and unqualified mathematics teachers, this poses a serious challenge. In addition, integration with other learning areas, requires teachers to have a much greater general knowledge of all learning areas, as well as the knowledge and skills necessary to identify relevant mathematical activities relating to these learning areas. Both forms of integration place an added time demand on teachers in terms of teacher preparation and in terms of having to meet with teachers from other learning areas (Adler, Pournara & Graven, 2000).

Integration could be particularly difficult considering the traditional nature of most mathematics teacher training. The emphasis on integration does not resonate well with the traditional absolutist philosophy that has dominated teacher training in South Africa. For many mathematics teachers and mathematicians, the power of mathematics is precisely its abstraction and it is assumed that learning it in its purest (rather than integrated or tied to particular situations) will enable it to be transferred to a wide range of situations. The result of these difficulties is that mathematics teachers

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entrance into universities.

have historically been left out of attempts to co-ordinate work along themes or as part of 'integrated–studies' [10].

What emerges from the analysis of Curriculum 2005 is that the practice of implementing MLMMS requires teachers to change their philosophical beliefs about mathematics and mathematics education, perform new roles and construct new identities in relation to these roles. I now turn to an analysis of the specificities of the roles demanded of MLMMS teachers.

What fashioning of mathematics teacher identities is demanded by the new mathematical roles inherent in MLMMS?

From analysis of curriculum documentation [11] it seems that teachers of MLMMS are expected to work simultaneously with four different orientations of mathematics. I have identified these as orientations in which:

1. Mathematics is important for critical democratic citizenship. It empowers learners to critique mathematical applications in various social, political and economic contexts. Mathematics is part of broader society and is important for all learners.

2. Mathematics is relevant and practical. It has utilitarian value and can be applied to many aspects of everyday life. Mathematics is part of broader society and is important for all learners.

3. Mathematics is an induction for learners into what it means to be a mathematician, to think mathematically and to view the world through a mathematical lens. Mathematics has its own beauty and can be explored for its own sake. Mathematical investigation and exploration (without necessarily utilitarian value) is emphasised. School mathematics in this sense is seen as part of a broader mathematics culture, which is produced and reproduced uncritically in accordance with the norms and conventions of the broader mathematics culture.

4. Mathematics is a language with conventions, skills and algorithms that must be learnt. Many of these will not be used or applied by most learners in everyday life but are important for the FET

[10] For example, Sacred Heart a private school in Johannesburg, is well known for its progressive education policies. It was one of the first schools to introduce 'integrated studies'. Mathematics however was the one subject that remained isolated and was not included in these efforts.

[11] I refer here to official policy documents of the NDE, district produced documents for workshops with teachers, illustrative learning programmes and progress maps produced by the Gauteng Institute of Curriculum Development (GICD) and the Gauteng Department of Education (GDE) etc.

band and for university studies in mathematics (for example, the symbols and conventions for writing exponents, factorisation of trinomials, solving Euclidean geometry riders etc.). School mathematics in this sense is seen as part of the broader mathematics culture, which is accepted and reproduced.

While I have presented these four orientations separately in order to provide a framework for analysing curriculum tensions, this should not imply exclusivity of the orientations. Rather these orientations should work together in support of each other. They too must be integrated wherever appropriate. An aim of the INSET project in this study was therefore to assist teachers in working with all four orientations of mathematics in an integrated way. This is discussed in more detail in Chapter 3. These orientations are embedded in the name *Mathematical Literacy, Mathematics and Mathematical Sciences*. *Mathematical Literacy* primarily incorporates Orientation 1, *Mathematics* primarily incorporates Orientation 3 and 4, and *Mathematical Sciences* primarily incorporates Orientation 2.

The four orientations relate to Bernstein's three competence models of education. Orientation 1 clearly strives for political empowerment and thus can be seen to reflect the values of a radical competence model of education. Orientation 2 and 3 strive for cognitive and cultural empowerment. They incorporate notions of learners constructing their own mathematical meaning and can be related to socio-constructivist influences. In this sense they incorporate the values of the liberal/progressive model. Ethnomathematics influences, which strive for cultural empowerment, among other things, located in Orientation 2 and 3 include values of a populist model of education. Orientation 4 strives to empower learners with conventions and algorithms necessary for all three other orientations. Thus aspects of all four of the above orientations of school mathematics can be found in MLMMS and in related documentation.

While four different orientations are identified in new curriculum documentation, these orientations are not always evident in practical interpretations (for example, illustrative materials, new forms of assessment etc.) of MLMMS. In many cases the orientations are presented separately from each other and in many cases Orientation 1 and 3 are overlooked. Integration of the four orientations will therefore require much work, and the application of a deep conceptual knowledge base, by teachers.

Unfortunately, there is little evidence of departmental support for teachers in doing this. Rather than presenting a view of mathematics that integrates all four of these orientations, support given to

teachers, in the form of provincially produced illustrative materials and 'support documents', often send out contradictory messages. These documents and materials often imply a preference for one orientation at the expense of others, leaving mathematics teachers feeling confused and pulled in different directions. This is well illustrated in the case of support provided to teachers in the Gauteng province. Official support on the implementation of Curriculum 2005 was provided to many Gauteng senior-phase mathematics teachers, in the form of pamphlets, workshops and illustrative learning programmes. These tended to emphasise the second and third orientation while viewing the fourth orientation (most familiar to teachers) as 'old' and needing to be de-emphasised. Evidence of this is clear in the Gauteng Senior Phase MLMMS Illustrative Learning Programmes (ILPs). These were designed by the GDE and the GICD to support teachers in developing theme-based and integrated learning materials.

The first Grade 7 ILP for MLMMS was called '*Module 1: Farming and Growth.*' Analysis of this fifty-page document revealed that only approximately one quarter of the activities related to mathematics and that most of these mathematics activities simply 'applied' mathematics skills (relating to the fourth orientation) assumed to already be available to learners. For example, Unit 1 involves four activities.

Activity 1, *Let us find out about farming*, involves a comprehension activity in which learners read information about farming, discuss farming and report back to the class.

Activity 2, *Working with large numbers* is a mathematical activity involving answering word sums such as 'About 1/3 of the earth's surface is used for farming. If the surface of the earth is 510 100 000 square kilometres, what is the area used for farming?'

Activity 3, *What is farmed in South Africa* and Activity 4, *Crop rotation* both involve activities aimed at increasing learner's general knowledge about farming in South Africa and are largely devoid of mathematical content.

This ILP has been heavily criticised by mathematics teachers[12]. Furthermore Chisolm *et al.* (2000) cite this ILP as illustrative that an emphasis on integration has meant that non-mathematical tasks have grown excessively and that the body of knowledge that defines mathematics has been obscured by non-mathematical considerations.

[12] Minutes of the AMESA Primary Mathematics Working Group meeting at the 2000 AMESA conference include

On the other hand official support provided to teachers aimed at improving 'performance' in schools (that is the implementation of Curriculum 2005 is backgrounded) emphasise the fourth orientation. This support, in the form of district level schemes of work and compulsory externally designed assessments, focuses on mathematical algorithms, procedures and definitions. Let me substantiate this with an example from my experiences of working with Soweto and Eldorado Park teachers at the start of this study.

At the start of my INSET work with the teachers in this study (February 1999) I was invited to a district level workshop for Soweto teachers. These teachers were invited to a previously 'white' school for the workshop. At this workshop the teachers from this school (all white teachers) provided the 'Soweto' teachers (all black teachers) with photocopies of their mathematics schemes of work. These schemes of work did not reflect any current curriculum developments and only focused on the fourth orientation of mathematics. The compulsory common assessments given to all Soweto schools in the district were based on this scheme of work and did not reflect any new curriculum developments (or any of the first three orientations). For example the exam asked learners to define various mathematics terms and excluded geometry because according to the scheme of work this is only dealt with in the final term. The justification for the insistence of the use of these schemes of work and assessments is that they are derived from a 'top performing' school in the district[13] [Journal, February 1999].

The Soweto teachers participating in this study were clearly offended. Such actions by the part of district workers, which undermine teacher efforts to implement new curriculum ideas and exclude teachers from making decisions related to the teaching and assessment of their learning area, affect the morale of teachers. Furthermore, they prevent, rather than support, teachers from developing new roles that resonate with the various orientations inherent in MLMMS and in the new curriculum more broadly. In a context of a post-apartheid South Africa the racial undertones of such an incident are particularly problematic and worrying.

It thus becomes clear that two contradictory official identities are being projected, that of the incoming curriculum and that of the outgoing curriculum. The Official Projected Identity of

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reflections on teachers' arguments that there is not enough mathematics in this ILP.

[13] This school is located in a wealthy northern suburb of Johannesburg. It is a well-resourced government school that is supplemented with funds from parents.

MLMMS in Curriculum 2005 emphasises the first and second orientation (although policy includes the third and fourth orientation but these are, in practice, less emphasised) while the Official Projected Identity related to the outgoing (but still predominantly implemented) curriculum emphasises the fourth orientation. Since there are currently two curricula existing within the school system, the incoming competence-based model and the outgoing performance based-model, provincial departments and district workers are in the difficult position of having to work out when it is appropriate to work with which Official Projected Identity.

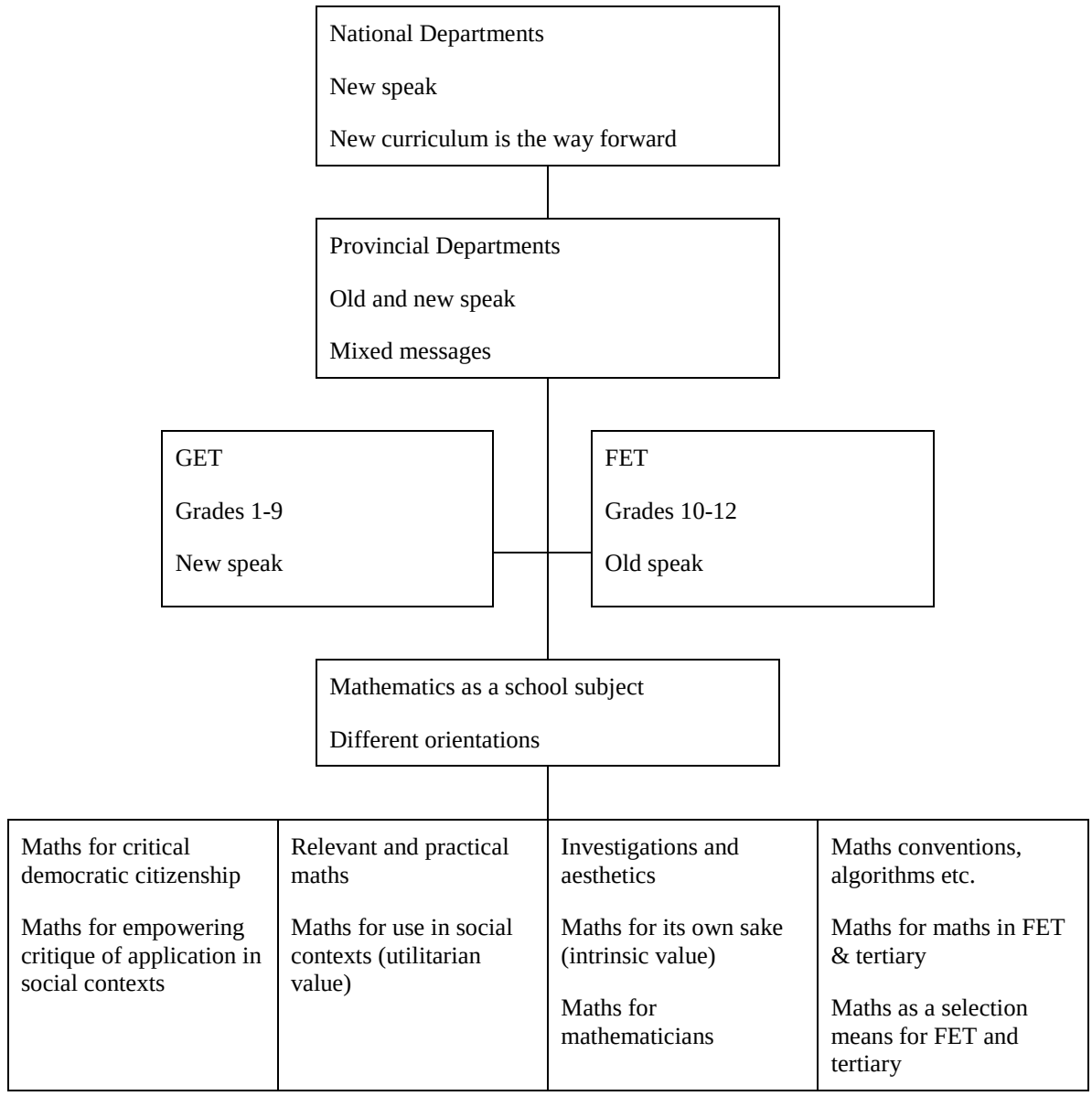
Under the pressure of needing to improve performance of schools [14], which is judged particularly in terms of matriculation results, district workers tend to stress the Official Projected Identity of the outgoing performance-based mathematics curriculum. Furthermore, since Curriculum 2005 has not been designed for the FET band (Grades 10-12) [15], the credibility of the first and second orientations is seriously undermined. The mathematics curriculum of the FET band is still that of the previous performance-based curriculum that largely excludes the first three mathematics orientations discussed above. The report of the review committee (see Chisolm *et al.,* 2000) also notes the disjuncture between MLMMS in the GET band and currently Mathematics in the FET band as problematic.

[14] Under the new Minister of Education, Kader Asmal, the discourse in the press around teachers, schools and education has been far more focused on improving performance than under his predecessor, Minister Bengu. Some examples of the increased focus on performance as reported in the press is the hard line taken with under-performing teachers, such as numerous threats to fire teachers and principals in poor functioning schools. Press statements indicate that schools with bad performance will be closed down. League tables emerge in the press during this time giving the top 100 performing schools.

[15] The National Curriculum Framework for Further Education and Training Draft Document was produced in May 2000 (NDE, 2000a). In this framework Mathematical Literacy will be part of 'Fundamental learning' and thus compulsory for all learners and 'Mathematics' will be part of 'Core learning' compulsory only to a particular qualification. A draft document for the Mathematical Sciences Standards Learning Outcomes and Associated assessment criteria for FET was developed in October 2000. Much negotiation and work is still needed for the design of a curriculum for this band (NDE, 2000b).

The following diagram sums this up.

Figure 2.2: Hybrid Orientations and Mixed Messages



Thus a process of pendulum swinging is taking place between the Official Projected Identity (OPI) of the outgoing curriculum (still implemented at FET and in practice throughout most grades) and the OPI of the incoming Curriculum 2005. In this pendulum swinging teachers are receiving contradictory messages. On the one hand, it is communicated to teachers that it is time to swing from their 'old and bad' practice to the 'new and good' practice, which emphasises the first two orientations (left hand side of table above) and, on the other hand, when performance and

examination results are important the fourth orientation (right hand side of the table) is emphasised. It is a central proposition of this study that this pendulum swinging is problematic and that all four orientations are needed for learners to become competent in MLMMS.

An understanding of school mathematics, in terms of the four orientations, demands that mathematics teachers develop related 'roles' in relation to their practice as a mathematics teacher. I identify four mathematics teacher roles relating to each of the four orientations described above. These roles must be overlaid with the roles for educators (for example, 'learning mediator') described in Chapter 1. The four roles are described below.

1. Resonating with the first orientation, the teacher's role is to prepare learners for critical democratic citizenship. The teacher becomes a critical analyser of the way mathematics is used socially, politically and economically in South Africa and supports learners to do the same.

2. The second orientation resonates with a teacher role as a 'local curriculum developer' and as, themselves being, an applier of maths in their everyday life. The teacher must be aware of the mathematics in the world around him/her, see the world through a mathematical lens and find ways to exploit this for teaching purposes.

3. The third orientation resonates with a teacher role of being a 'mathematician' (themselves) or being someone with an interest in pursuing mathematics "for its own sake". In this role the teacher apprentices learners into a ways of investigating mathematics and provides insight into the world and work of 'mathematicians'.

4. The fourth orientation resonates with a teacher role as a 'custodian' of mathematical knowledge and teacher of mathematical language, symbols, definitions, conventions, theorems, discoveries, and algorithms (which are important for MLMMS in general and for preparation for the FET band). The teacher in this sense is the 'master' or 'exemplar' and 'conveyor' of the practices of the broader community of people with an interest in mathematics.

The diagram below provides a summary of the above.

Figure 2.3 Four different orientations and four teacher roles inherent in MLMMS

Maths for critical democratic citizenship Maths for empowering critique of application in social contexts	Relevant and practical maths Maths for use in social contexts (utilitarian value)	Investigations and aesthetics Maths for its own sake (intrinsic value) Maths for mathematicians	Maths conventions, algorithms etc Maths for maths in FET & tertiary Maths as a selection means for FET and tertiary
Maths as part of broader society Critical analysis of maths in social contexts Maths for all South Africans		Maths as part of a mathematics culture Uncritical reproduction of maths culture Maths for mathematicians or FET learners	
Mathematics Teacher Roles			
Teacher prepares learners for critical democratic citizenship Teacher as critical analyst of the use of maths in society "I analyse and critique the maths structures in society"	Teacher prepares learners for use and application of maths in social contexts Teacher as applier of maths in social contexts "I have a way of using maths in various social contexts"	Teacher prepares learners as apprentice mathematicians Teacher as mathematician "I have a mathematical way of working"	Teacher prepares learners for success in Grade 12 and FET Teacher as competent at school mathematics "I am competent in the use of school maths conventions and I can pass these on to you"
Teacher – local curriculum developer ?		Teacher as deliverer of prescribed curriculum ?	

In Summary:

It has been argued that analysis of curriculum documentation for MLMMS Curriculum 2005 reveals a radical shift in the philosophy of mathematics of the previous curriculum in terms of the approach to mathematics teaching and learning, the nature and contents of mathematics and the role of mathematics. Furthermore MLMMS combines four different orientations to mathematics that

can be related to four different roles expected of teachers of mathematics. In Bernstinian terms, MLMMS combines features of all three competence based models in its attempt to enable cognitive, cultural and political empowerment through mathematics.

I have discussed several MLMMS implementation difficulties particular to the South African context and particular to the learning area of MLMMS. The situation of the phasing-in of curriculum 2005 creates confusion for educators. This is exacerbated by the fact that Curriculum 2005 is currently only available for the GET band. Thus, contradictory education models (performance-based and competence based) co-exist in this transition period. In the context of the lack of capacity within departments to interpret the curriculum and support teachers (see Jansen and Christie, 1999; Taylor & Vinjevold, 1999) these difficulties intensify. This creates dilemmas for teachers whose schools continue to be judged (by departments, parents, the press and learners) on the performance of learners reflected in Grade 12 examinations. This is especially true for teachers who teach mathematics across both FET and GET grades.

The diagram on the following page summarises some of the main curricula changes discussed in this chapter.

Chapter 3: The empirical field and its relationship to the research

This thesis investigates mathematics teacher learning within an INSET practice stimulated by curriculum change. The INSET practice that forms the empirical field for this thesis is the Programme for Leader Educators in Senior Phase Mathematics Education (PLESME). This programme was developed in the context of the broader political and educational changes and particularly focuses on enabling teacher engagement with the mathematics curriculum changes described in the previous chapters. Since PLESME forms the empirical field for this thesis it is important that I provide some information about the nature of the PLESME practice and my role in it. Furthermore, since the PLESME project and its evolving design are inextricably connected to this research, and since the dialectical relationship between them is potentially confusing, I have endeavoured to clarify some of the ambiguity by dealing primarily with the design of PLESME in this chapter and the design of the related research in Chapter 4. I nevertheless provide continuous cross-referencing to the dialectical relationship between them.

This chapter is divided into four parts in which I describe:

Part 1: My role in PLESME.
Part 2: The rationale for the design of PLESME.
Part 3: Describing the participating teachers and schools in PLESME.
Part 4: Describing the nature of PLESME.

I begin the chapter with a necessary prelude about what PLESME is and an explanation of my dual role in it.

What is PLESME?

PLESME was a two-year INSET programme based at the Centre for Research and Development in Mathematics, Science and Technology Education (RADMASTE), in the University of the Witwatersrand, Johannesburg. The primary aim of PLESME was to create leader teachers in mathematics with the capacity to interpret, critique and implement current curriculum innovations in mathematics education and to support other teachers to do the same. A major focus that emerged in PLESME was the creation of a supportive community of teachers and INSET providers, located

within the broader profession of mathematics education. This supportive community was seen as a means to sustaining teacher learning beyond the life span of the project.

At the start of PLESME, the nature of the certification that teachers would receive was unclear. Teachers were promised certificates explaining the nature and duration of the course. I undertook to work towards getting the programme accredited and registered with the South African Qualifications Authority (SAQA) as soon as the structures were in place for me to do so. In October 2000 the course was registered with SAQA. The certificates would enable teachers to build credits towards other SAQA registered courses and would provide 'evidence' of teacher compliance to the mandatory 80 hours per anum of INSET. Assessment was portfolio-based. Portfolios included, for example, teacher conference presentations, materials and booklets designed by teachers, teachers' input into the Report of the Review Committee on Curriculum 2005, workshops teachers organised and ran, classroom videos and teachers' written reflections on lessons. The certificate that was awarded to teachers is included in Appendix 2.

Part 1: My role in PLESME: Co-ordinator of, or Researcher in, PLESME?

In PLESME I wore two 'hats'. Firstly I was the co-ordinator of PLESME. I raised funds for it, designed it, set up a steering committee, negotiated with schools, districts and teachers as to the location and nature of the of the project and delivered it. This was my full time vocation for the period of October 1998 to December 2000 and I was accountable to my organisation, the university, the PLESME steering committee, donors, teachers and schools on the value and 'success' of the project. At the same time, I was a doctoral student in the process of developing a proposal for research in mathematics teacher education.

The proposal I submitted in December 1998, stated that I intended to research teacher learning in an INSET programme structured to enhance participation in a community of practice in the context of curriculum change. The research proposal and PLESME were therefore developed simultaneously and PLESME provided a potentially rich empirical field for my study of teacher learning. From October 1998 to December 2000 I became both the co-ordinator of PLESME and a researcher in PLESME.

Teacher interviews, teacher questionnaires, videos of teachers' lessons, and my personal journal were important features of PLESME irrespective of the research agenda. These enabled an action-reflection cycle, which enhanced both sensitivity and reactivity in PLESME. These also provided data sources for research on teacher learning. The possible use of these as data sources was of course negotiated with teachers and I discuss this more fully in relation to the research methodology in Chapter 4. In the two years of PLESME my role as 'researcher' primarily involved unstructured participant observation, semi-structured teacher interviews, systematically collecting and filing PLESME work as data, keeping a reflective journal and reading a wide range of literature relating to both teacher development, research methodologies and socio-cultural and social-practice theories of learning.

My dual role as a difficult tension or powerful praxis?

I was expecting some difficulty and tensions to emerge in relation to my role as 'PLESME co-ordinator' and my role as 'researcher.' This was primarily because I had struggled to distinguish these roles clearly in the research proposal. I discovered, however, that no such tension emerged in practice and that the tension remained primarily theoretical. Instead I discovered a very powerful praxis in the duality of being both INSET worker and researcher. It enhanced and enabled a form of action-reflection practice that I had been unable to achieve with success in previous INSET projects.

For example, reflecting on interviews, lessons and other data helped me to develop research ideas and refine my research objectives. It led to me to ask specific questions in interviews and questionnaires that related directly to my research interest in understanding the nature of teacher learning. However such reflection on data also led to the replanning of PLESME activities and the design of additional activities that would enhance teacher participation and teacher learning. Thus for example, interviews became a combination of discussions as a necessary part of praxis and discussions that were geared towards gathering data necessary to assist me in answering my research questions. In many cases discussions served both purposes and it is difficult to separate the two in practice.

Similarly my ongoing reflection in the form of journal entries (relating both to my work as PLESME co-ordinator and my work as a researcher) and the literature I was reading helped me to

reflect on how to improve PLESME. Thus, the two roles were inextricably intertwined in my praxis. The time-line of PLESME activities (see Appendix 3) discussed in Part 4 illustrates this intertwined and reciprocal relationship more clearly.

I found enormous advantage in this duality of roles. Working closely with teachers in PLESME helped give form to the research and the research process *and* enabled more sensitivity and reactivity by myself in PLESME. My own learning in terms of becoming a more experienced 'INSET provider' was maximised by the ongoing reflection, stimulated by the research. Of course this was enhanced by the choice of my research focus, which was to understand the nature of teacher learning in relation to an INSET practice. Indeed any person working in INSET (especially at this time in South Africa) should be reflecting on their practice for the purpose of maximising the benefits of the INSET and for their own learning.

In this sense the emergence of 'powerful praxis' rather than a 'difficult tension' is something that all INSET providers should be working towards. Mason (1998) argues that one of the most significant products of research is the transformation in the being of the researcher. Through this 'powerful praxis' I became a more sensitive INSET provider and through the dynamic nature of the INSET I became a different type of researcher. In this sense I believe that the research produced its most significant product.

However, as I was warned, disentangling this duality would be difficult. At the start of the research I was warned of the potential for confusion between the INSET programme and the research[1]. Indeed, this powerful relationship is theoretically difficult to unpack. For the purposes of the research it is important to disentangle my role as researcher and INSET co-ordinator. How does one do this in such a way as to meet the requirements of 'rigorous' research without backgrounding the significance of the interrelationship between PLESME and the research?

This clearly has been a major challenge for the research. In reality the two were intertwined. In practice I managed the duality by primarily wearing my INSET hat for the two and a half years of my involvement in PLESME. I focused my attention on enhancing teacher learning within PLESME as much as I could. Once PLESME was completed I shifted my focus to the research and

1 This warning came from one of the reviewers of my research proposal.

became primarily a researcher with a goal to analyse teacher learning for the purposes of understanding that learning better and for the purposes of writing valuable and rigorous research.

Thus, while during PLESME I could not and did not try to separate my roles, for the purposes of providing clarity for the reader, I have chosen to describe the PLESME process (in this chapter) separately from the research process (Chapter 4). However, since the two processes are inextricably linked and mutually constituted I provide descriptions of the interconnectedness throughout each of these chapters.

In the next part of this chapter I describe how and why PLESME came about (its practical and theoretical influences). I describe the teachers and schools involved in PLESME and the nature of PLESME activities and its underlying assumptions.

Part 2: The rationale for the design of PLESME: confronting practical and theoretical dilemmas

As explained above, the design of PLESME evolved with time. It was influenced by changing circumstances in the broader context of ongoing changes in education, changing local factors in relation to the schools and teachers and by my own changing ways of thinking about the main purposes of PLESME and how best to achieve them. The latter was strongly influenced by my ongoing reflection on the project and related data gathering processes and by my progressive focus on literature relating to learning from a social practice theory perspective (in particular Lave & Wenger, 1991; and later Wenger, 1998). Not surprisingly it is therefore difficult to sketch in a linear fashion the story of the development of PLESME.

After much reflection and analysis of my journal entries (from October 1998 up to December 2000) and various documents I produced relating to PLESME during this time (e.g. course handouts, certificates and annual reports) a framework of key dilemmas emerged in relation to the evolution of the deign and purposes of PLESME. It therefore seemed most useful to structure my description and explanation of the design of PLESME (the nature of its emergence and evolution) not chronologically but rather in relation to the confrontation of the practical and theoretical dilemmas that I confronted during the project. It is to this that I now turn.

These dilemmas emerge from the broader context in which PLESME and this study take place, described in Chapter 1 and Chapter 2. The dilemmas are not presented as 'either/ors.' In the design of an INSET project, decisions must be made as to the duration, scale, site, participants, focus and ethos of the intervention. In this chapter I unpack the dilemmas confronted in relation to these design features and provide some rationale for the decisions I made in the case of PLESME. The six key dilemmas are:

1. The dilemma of duration and scale.
2. The dilemma of site.
3. The dilemma of focus: mathematics versus methods.
4. The dilemma of ethos: necessary change or learning as a life-long process.
5. The dilemma of my racial being in the context of a post-apartheid South Africa.
6. The dilemma of who participates in PLESME.

I deal with each of these separately.

1. The dilemma of duration and scale

In South Africa the enormous shortage of qualified mathematics teachers highlights a desperate need for both PRESET and INSET. The new curriculum adds further pressure to this need. It is widely accepted that current curriculum initiatives in South Africa demand that attention be given to teacher support, especially in the field of Mathematics, Science and Technology, in the form of INSET. Underlying this belief in the urgent need for INSET, is the assumption that teachers need to change their existing beliefs, knowledge and practices. This assumption is derived from research (see Taylor & Vinjevold, 1999) that indicates that most teachers in South Africa function within a traditional performance-based model of education.

This traditional paradigm does not however cohere sufficiently with current mathematics curriculum reforms, which emphasises the construction of mathematics as a human activity in an attempt to understand the world and emphasises a competency-based model of education. As discussed in Chapter 1 and 2, teacher roles have been redesigned and teachers are expected to develop their practice so as to 'fit' more closely with the roles, philosophies and values underpinning the new mathematics curriculum. So far little has been done to encourage and support

teachers in understanding the implications of the new curriculum for classroom practice (Jansen, 1999; Chisholm *et al.*, 2000).

In South Africa, as in other countries, there has been much frustration with the seemingly low impact of INSET. The use of a cascade model by the NDE in preparing teachers for the implementation of curriculum 2005 has proved ineffective. In this model officials from each province were trained as 'master trainers' who cascade the knowledge to district officials who in turn cascade the information to teachers and educators in their district. Various problems were identified with this model, including the 'watering down' and/or misinterpretation of crucial information and the lack of confidence, knowledge and understanding of trainers (Chisholm *et al.*, 2000). Other criticisms are that such training, which is in the form of 2-3 day courses, is far too short and offers no follow-up support for dealing with classroom implementation. Despite the ineffectiveness of such courses, this is still the dominant training model used in South Africa (Chisholm *et al.*, 2000).

As explained in Chapter 1, a major influence on this study was my earlier experiences as an INSET provider and researcher of that INSET. These experiences similarly influenced the design of PLESME. In earlier research (Graven 1997, 1998), I examined the 'impact' of a limited number of workshops (6-8) and classroom visits (1 per teacher) over a 6-month period with various groups of senior-phase mathematics teachers. These workshops aimed to support teachers in developing an understanding of mathematics learning and teaching from a socio-constructivist and learner-centred perspective. The research showed that while workshops enabled teachers to express more socio-constructivist and learner-centred views about mathematics teaching and learning, these views were in most cases not evident in practice. In short, the design of the INSET had failed teachers and failed to meet the intended outcomes of the intervention.

These experiences prompted me to reject short-term INSET and to rather actively seek funding for longer-term, classroom-focused INSET in which schools and teachers volunteer to participate in INSET rather than being compelled to do so. Thus my experiences led me to design PLESME as a long-term, intensive and classroom focused project. This design, in turn, impacted on the scale of PLESME.

Classroom-focused INSET implies a need to support teachers in their classroom practice and this results in a highly labour intensive design that is difficult to expand to a large number of teachers without a large increase in resources (both financial, material and human). PLESME was local. It involved a limited number of schools and mathematics teachers in relatively close proximity to the University of the Witwatersrand. This was determined to some extent by funding constraints and by a belief that in order to be effective I needed to work intensively with teachers and provide regular classroom-based support. This meant that short of a much larger budget and increased resources (people and equipment) the number of participating teachers and schools had to be kept small.

A dilemma emerged in this respect. Clearly, currently in South Africa, INSET is needed nationally on an enormous scale. At present however there are not sufficient resources to provide wide scale intensive INSET. Small, localised projects such as PLESME can only support a few teachers. This creates a privileged situation where a few teachers have access to a lot of resources, while the majority of teachers are left with very little. While I do not believe that there are clear solutions to this tension it is useful to note that this tension is being increasingly acknowledged in policy and strategy documents. Kahn (2000) captures this tension, 'dispersed low unit cost intervention may not work, but concentrated high cost intervention may succeed. How then to compare costs?' (p.18).

Bisseker (2000) sums up the related debates that are currently emerging in South African education:

> There is concern, though, that a strategy that creates more pockets of excellence will battle to find political acceptance. Sadtu and Cosatu president Willie Madisha grumbles that 'identifying two or three schools and leaving the majority is just out of order', but Kahn and Asmal say this is not politically sensitive. "If you have limited resources, then you target 10-12 schools in each province and they become exemplars," says Asmal. "That doesn't mean you give up the quest for equity. If you spread the margarine evenly, you're not making any impact (p.3).

The 'compromise' that emerged from the implication that longer-term intervention demanded smaller-scale design was to focus PLESME on the development of 'leader' teachers. In this way, while the project remained small the number of teachers influenced by the project could be far larger. I expand on this briefly.

While teachers involved in PLESME were privileged in terms of access to resources, they were expected to take on leader roles so as to support a much wider range of teachers in understanding the new curriculum. Thus the primary aim of PLESME was to create leader teachers in mathematics with the capacity to interpret, critique and implement current curriculum innovations in mathematics education and to support other teachers to do the same. This should not be confused with cascade models. Teachers were not expected to pass on what they learnt in the same way but rather were expected to take on a wide range of leadership roles according to their strengths, the contexts they were working in and in relation to the communities in which they participated. This vision of 'leader teachers' would therefore support the development of learning communities as envisaged in the Teacher Supply Utilisation and Demand Strategy (TSUD). Musker (1998) explains that the TSUD policy framework 'centres its vision on a community of committed, competent and reflective teaching professionals who can organise systematic learning and help to establish and sustain peaceful and purposeful learning environments' (p.6).

2. The dilemma of site

INSET projects are often described as either school-based (i.e. most of the activities of the project take place in schools) or institution-based (i.e. most of the activities such as workshops and discussions take place at the premises of service providers). Clearly many INSET projects are a combination of these. In the case of PLESME, its administrative functions were based at the RADMASTE centre, workshops were based at one of the schools of participating teachers and school visits occurred in each of the participating schools. PLESME drew teachers from many different schools, drew presenters from a range of different institutions (e.g. Wits University, RADMASTE, independent consultants etc.) and focused on classroom practice, which included classroom-based support. I therefore struggled to find a description that adequately captured 'the site' of PLESME. The description of PLESME as a community of practice-based project with a classroom focus emerged as a means of capturing some of the complexity in relation to 'site'. In this description the dilemma of systemic school-based versus institution-based INSET was subverted. I expand on this briefly with some reference to the emerging literature on communities of practice.

I began the design of PLESME with what for me was a ‘common sense’ assumption that learning would best take place in an environment where collegiality, co-operation and support was encouraged and enabled. I developed this assumption from my own experiences of learning as both a student and teacher. I had participated in and ‘set up’ various ‘support groups’ to assist me in developing myself as a researcher. These involved reading groups, discussion groups, seminar series, and informal dinners with colleagues and friends who were conducting similar research. The support from colleagues in these groups and the opportunity to collaboratively engage on issues relating to various readings, qualitative research, ethical debates and so forth were enormously helpful.

In these forums I was supported in: articulating tensions and dilemmas; learning from strategies colleagues had used; sharing and locating relevant resources; drawing on emotional support and developing a sense of identity in relation to what it currently means to be a qualitative researcher in the field of mathematics education. These personal experiences led me to examine how teacher learning could be enhanced through similar support structures in the context of INSET.

This ‘common sense’ assumption was also influenced by literature and research in the field of mathematics teacher education that argues for the importance of collegiality. For example Blaik & Atkin (1996) in their review of various projects that focus on teacher collaboration argue that collaborative support (both amongst teachers and between teachers and innovators) can reduce teacher isolation, foster professional enthusiasm, encourage innovation and boost teacher confidence. Thomson & Holloway (1997) argue from the basis of a wide range of research conducted in schools that a ‘culture of collaboration’ is an important condition for successful implementation of educational change. They argue that educational change meets with more success in schools where teachers regularly support each other and that in such schools teachers have greater confidence and commitment to improvement.

The notion of a ‘supportive community’ for teacher education is increasingly gaining recognition in the literature. For example, some refer to ‘intellectual communities’ (Wilson & Berne, 1999), ‘communities of practice’ (Lave & Wenger, 1991; Wenger, 1998) and ‘professional communities’ (Secada & Adajian, 1997). They all have in common the notion that a community provides space for the development of discourse necessary for learning.

Secada & Adajian distinguish communities from professional communities.

> A community is a group of people who have organised themselves for a substantive reason; that is they have a shared purpose… A professional community is distinguished from other forms of community in that it is organised professionally (p.194).

They operationalise their conception of mathematics teachers' professional communities along four dimensions: a shared sense of purpose, a co-ordinated effort to improve mathematics learning, collaborative professional learning and collective control over important decisions. In this respect I considered PLESME to be a professional community.

Another important aspect of supportive communities relates to professional teacher associations, also referred to as 'professional networks' (Wilson & Berne, 1999). Many authors believe that such associations are important because they provide a forum where mathematics teachers can develop discourse related to their profession and take collective control over decisions. The importance of linking PLESME teachers to such professional associations was an idea that emerged from work in PLESME. Furthermore, participation in a professional association would support the teachers to perform various roles envisaged in the norms and standards document for educators (discussed in Chapter 1) namely the roles of researcher and life-long learner, community and citizenship, and learning area specialist.

I chose the term 'community of practice' (Lave & Wenger, 1991; Wenger, 1998) to describe PLESME because its broadness incorporates the above notions of collegiality, co-operation, support and professional communities. The PLESME professional community of practice overlapped with professional associations (or networks) and was embedded within the broader profession of Mathematics Education. For Lave & Wenger (1991) a community of practice is:

> a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice. A community of practice is an intrinsic condition for the existence of knowledge… (p.98).

Locally, the discourse of collegiality and co-operation is increasingly gaining recognition. In Curriculum 2005 teachers are encouraged to work together, share ideas and teach jointly with

others in some learning areas (NDE, 1997). The TSUD document centres its vision on a committed community of teaching professionals who can sustain learning environments (Musker, 1998). The importance of professional associations is also noted in South African literature relating to teacher education. Kahn (2000) notes that AMESA (the Association for Mathematics Education of South Africa) and SAARMSTE (the Southern African Association for Research in Mathematics Science and Technology Education) have played an important role in strengthening subject work and building research capacity.

At the start of PLESME the relationship between collegiality, co-operation and communities of practice was unclear and these ideas continued to develop and form throughout the project. PLESME began with a focus on creating a supportive community of practice for teachers in which collegiality, co-operation and support were features of that practice. With time PLESME extended this notion to developing a supportive community of practice within the broader professional community of mathematics educators. PLESME conducted fieldtrips to various professional associations, district offices and teacher centres, and provided input into curriculum developments and mathematics teacher conferences. In this respect, locating the PLESME community of practice within the professional practice of mathematics educators became a central activity of PLESME.

This development led me once again to reconsider the description of the 'site' of PLESME. Initially I had referred to PLESME as being school-based rather than institution-based but later described PLESME as being classroom-focused and community of practice-based. In relation to the location of PLESME within the broader professional community, the site of PLESME is best described as a community (comprised of individuals from schools and institutions) of practice-based, classroom-focused intervention. This intervention is located (and networked) within the broader professional practice of mathematics education.

3. The dilemma of focus - mathematics versus methods

Currently in South Africa 50 percent of the teachers of mathematics have less than a Grade 12 mathematics qualification (Kahn, 2001). The mathematics qualifications of the PLESME teachers reflected these national statistics. Thus while the participating teachers of PLESME came into the programme as *teachers of mathematics* the majority of teachers had not studied or intended to become *mathematics teachers*. Many PLESME teachers taught mathematics because it had been

the only teaching post available or because no one else wanted to teach it or because they had studied some mathematics at school and therefore were considered the most qualified to teach it.

The PLESME teachers shared many stories of how they became *teachers of mathematics* by 'default'. For example, Moses explained that it was not considered politically acceptable as a black student to study mathematics when he was at school and college. Rather one had to study history and other subjects, considered important for the struggle against apartheid [Journal, August 2000]. Moses had therefore studied to become a history teacher but became a teacher of mathematics because there was a shortage of mathematics teachers at the school to which he applied. Another teacher Barry, despite having taught mathematics and headed a mathematics department for many years, explained that he was *not* a mathematics teacher since he did not even study mathematics at high school. He preferred to call himself an art teacher since this is what he had studied [Journal, October 1999].

The examples above illustrate that an effect of South Africa's apartheid history on the PLESME teachers was that while all were *teachers of mathematics* most were not *mathematics teachers* by training or by choice. They had not studied to become mathematics teachers and they did not necessarily identify themselves as mathematics teachers. The challenge for PLESME was therefore to help teachers to 'become' *mathematics teachers* in terms of both mathematical competence and identification. That is to become confident mathematical thinkers, to develop deeper mathematical and mathematical pedagogical content knowledge and to become part of the broader community of mathematics educators. Thus a focus of many PLESME activities was to develop and deepen mathematical knowledge.

This was addressed in many ways. In some workshops teachers investigated mathematical situations such as the probabilities involved in the newly launched national lottery, the derivation of equations from real life contexts and their range of representations (for example, patterns, tables and graphs). In some workshops teachers explored various outcomes such as those involving mathematics as it is embedded in various social, political, economic and cultural contexts. For example, teachers critically examined graphical representations of the results of national elections and the national budget. In other workshops teachers debated new curriculum methodologies such as learner-centred practice, group work and continuous assessment, but these were always located within the practice of mathematics teaching. Thus, while sometimes PLESME focused on

mathematics *per se*, in most cases mathematics was explored in relation to teaching at the senior-phase level. In this respect, mathematical knowledge and mathematical pedagogical knowledge were intertwined in PLESME workshops.

In Chapter 2, I identified four different orientations towards mathematics in new curriculum documentation. These are: mathematics as important for critical and democratic citizenship; mathematics as relevant and practical; mathematics as induction into the practice of mathematicians, and mathematics as a body of knowledge involving conventions, skills and rules (also necessary for the first three orientations and for proceeding to study mathematics further). Each of these orientations were dealt with in workshops and there was a strong emphasis on assisting teachers to work with all four orientations rather than merely focusing on one or two orientations at the expense of the others. Thus PLESME embraced the new definition and outcomes of MLMMS while not undermining the more familiar mathematical orientation of mastering necessary basic mathematical skills.

There is much research in South Africa indicating that in many INSET projects, teachers adopt 'forms' of learner-centred practice at the expense of developing mathematical meaning and working conceptually with the mathematics (Brodie *et al.*, in press). And indeed the Report of the Review Committee (Chisholm *et al.*, 2000) warns of the watering down of mathematical content in the interpretation of MLMMS. There is a clear danger in the implementation of the new curriculum for mathematics teachers to adopt the pedagogical forms without necessarily assisting learners to develop mathematical meaning. In an attempt to prevent this dichotomy, PLESME aimed to work with both mathematical meaning and pedagogical forms simultaneously.

4. The dilemma of ethos: necessary change or learning as a life-long process

During my work as an INSET provider I processed an important shift in my conceptualisation of the primary purpose of INSET. Previously I had viewed INSET as being primarily about achieving teacher change but experiences led me to a broader and more open conceptualisation of INSET as being primarily about stimulating and supporting a life-long process of teacher learning. While this shift might seem subtle or merely a change in terminology, in effect, it was very significant in changing my 'being' as an INSET worker. I briefly expand on some of the influences that led to this shift in conceptualisation.

A review of the literature on teacher development indicates a focus on teacher change. The term teacher change is particularly problematic in the South African context where curriculum support materials set up dichotomies between 'old' and 'new' practices and refer to 'old' practice as 'bad' and 'new' practice as 'good'. These documents call for radical teacher change where old practice is completely replaced by new practice. Once this has happened the learning process is complete. What happened to the idea of learning as a life long process? Such a view of teacher change is clearly disempowering for teachers and furthermore is not educationally sound. Related to this idea of change from 'bad to good' practices is a 'fix-it' approach to INSET. Breen (1999) argues that the manifestation of INSET Culture seems to have the following principle:

> There is something wrong with mathematics teaching world-wide, and that we, as mathematics educators, must fix it. Many mathematics teachers have bought into this culture. Such teachers seem to be seeking new ways to fix their practices…Mathematics teachers need someone to fix them, and mathematics educators need someone to fix…This culture is based on judging what is right and wrong, paying little attention to what mathematics teachers are actually doing (since it is wrong anyway) in their classrooms, and looking outside themselves for the 'right' way, the newest 'fix' (p.42).

I earnestly wanted to move away from this deficit 'fix it' approach but was stuck with the dilemma of if I thought teachers did not need to change, then why work with them. This was put to me in a steering committee meeting in which I was explaining that I had used an initial PLESME workshops to show snippets of the teachers videos to demonstrate the extent to which much of what they were doing in classrooms resonated with the 'new' curriculum outcomes and learner-centred methods. The challenge was that if teacher practices were already 'good' then why work with teachers? This challenge however assumes that learning is only valuable if one has little knowledge to begin with and overlooks the importance of drawing on existing knowledge as an important learning resource and contradicts the philosophy of lifelong learning.

Ensor (2000) argues that the task of many in-service providers is to make available to teachers the particular embodiment of 'best practice' that they are privileging. My picture of 'best practice' was, however, not clear, and I believed that 'best practice' was dependent on the knowledge (in its broadest sense) of the teacher and the classroom context that the teachers was in. Such contexts can

be vastly different from one school to the next. I spent much time resisting teachers' expectations that I knew what the ideal 'new curriculum' lesson was and could and would explain to them how to do it. This is not to say that I did not have my own preferences or principles of selection that influenced the nature of the workshops and the methodologies that I drew on for workshops, or the comments I made on teachers' lessons and the nature of PLESME activities. I experienced a tension between making explicit to teachers the principles (values) I was drawing on and my preferences for teaching, while at the same time holding back judgement and notions of 'best practice'.

An emergent assumption of PLESME was that the implementation of the new curriculum did not simply involve following a set of curriculum instructions or replacing 'old' practice with 'new' practice. Rather implementing the new curriculum was a process of fashioning the curriculum in such a way that it became part of the teacher's 'way of being' (Lave & Wenger, 1991). This would be best enabled through providing teachers with a range of resources (relating to mathematics content, methodological ideas, access to 'new' discourses, materials, curriculum documents, mathematics educators etc.) so that teachers could experiment with these and reflect on them in a supportive community. In fashioning the curriculum in this way, teachers would 'change' themselves and modify the curriculum. This assumption was supported by a range of comments from PLESME teachers and is captured by the following comment by one teacher: 'You know before I always used to introduce myself as the music teacher, now I introduce myself as the maths teacher' [Beatrice Interview, July 1999].

As stated above, these assumptions were not clear to me at the start of the research study but rather developed over time through working with teachers who were making sense of the new curriculum and reflecting on their learning process. In January 2000 I attended the 8th annual SAARMSE conference. While attending a talk by a speaker on INSET I was struck by the similarity in his research approach and my research approach two years previously. That is an impact study around the extent to which teachers changed according to a predefined schedule of expected change. The results too were similar, that is they revealed very little teacher change. I reflected on this session in my journal:

> It (the session) made me ask myself why the talk of 'change' felt wrong, arrogant and over-simplistic. How was my talking about teacher learning as the fashioning of identity within a practice different? The term 'change' and knowing what beliefs teachers must have worried

> me a lot. I'd been there only one and a half years ago. Where had I shifted to if at all or was I just finding more PC (politically correct) ways to describe something? [Journal, 24 January 2000]

I continued in my journal on this issue and tried to unpack how PLESME was different:

> So PLESME was different in the sense that it did not provide a template of the ideal teacher. Yes certain principles were emphasised but in a sense it (PLESME) was structured to give teachers access to a wide range of resources – maths educators, forums for discussion and reflection, reflection on lessons – and through videos allow teachers to develop and consolidate their own individual understanding of their place in the 'new practice' of PLESME and the new curriculum [Journal, 24 January 2000].

Thus from the beginning of the INSET and my research, I wanted to focus on understanding learning rather than just doing an impact study in terms of what had changed according to a predefined set of criteria for evidencing this change. I had shifted to being able to articulate that PLESME was about access to a range of resources and participation in a supportive and reflective community of practice. Granted, in the PLESME practice I brought principles and philosophies about mathematics education that resonated with the new curriculum but these were not prescribed but rather available for experimentation, adaptation and discussion. Thus, I came to see teacher learning as activated rather than delivered (Wilson & Berne 1999).

5. The dilemma of my racial being in the context of a post-apartheid South Africa

In the same way that the teachers involved in PLESME and in the research are described in racial terms and in terms of their educational experience, so too is it important that I become racialised in the description of myself in relation to PLESME.

So who am I?[2]

I am a white, female, English-speaking South African. I studied a Bachelor of Science in Education Degree in which I majored in mathematics, a Bachelor of Science Honours degree in Mathematics

2 Adler (1996) similarly asks this question in her research and I have based the style of my description on her work.

Education and a Masters of Philosophy in Mathematics Education. I was a mathematics teacher for four years at a very well resourced urban private non-racial school. For the past six years I have been employed as a Research and Development officer, at RADMASTE, where I work on a range of mathematics INSET projects, input into curriculum documents, learner materials and conduct research relating to the 'impact' of various projects.

I speak mainly English although I can speak and understand basic Afrikaans. My knowledge of African languages is minimal and I can only basically greet people (and sing a couple of songs) in Zulu and Sotho. The significance of this is that I do not share the primary language of the teachers from Soweto whose primary languages are Northern Sotho, Southern Sotho and Zulu. All of the participating teachers from Soweto can speak English and use it in their teaching. Half of the teachers from Eldorado Park have English as their primary language while the other half speak primarily Afrikaans. Since many of the Eldorado Park schools are dual medium, most of the teachers teach mathematics in both English and Afrikaans. Thus all the teachers can speak and understand English, the dominant language used in PLESME workshops (in pair and group discussions other languages were sometimes used).

Working with sensitivities and raising the issue of 'race'

As I outline my race and primary language, I am aware that there are many related issues of power and culture. At the start of PLESME I was quite naïve to these issues and did not consciously reflect on them. On a personal level I felt comfortable with the relationships I had developed with teachers in the past few years of conducting INSET and felt that my ability to develop positive working relations with teachers was a strength. The issues however began to confront me on a theoretical and ethical level since I was now conducting research which involved personal gain (i.e. work towards a doctorate). In doctoral seminars debates were emerging about what it meant to be a white researcher in black schools. Was this ethical? We read Mahlomaholo & Thabang's (2001) paper '*Knowledge production in Mathematics, Science and Technology Education among the poor as a contested terrain: The case of South Africa*' which takes issue with the race, positioning and intentions of researchers in African schools.

> What we propose is that all researchers before making sweeping and judgemental 'findings' about African teachers (learners etc.) need to conduct an intensive introspection about

> themselves, their mission, agenda and procedures. From such an introspection it shall become clear that the proposed research is not value-neutral, that it is mounted on the racially inspired premises that African teachers have a problem that the researchers can fix (p.4).

This paper provoked much debate in our doctoral group as to ethical concerns related to white researchers in black schools. From these debates, various questions emerge, for example: Do you have to be black to conduct research with black teachers? If research and development work mainly occur with black teachers does this imply that black teachers are more 'deficient' than white teachers? What constitutes racial sensitivity on the part of researchers and INSET providers? These are important and difficult questions and resulted in my confrontation of the dilemma of my own race in the context of working with teachers from different race groups in a post-apartheid South Africa. It is beyond the scope of this study to deal with these questions in detail, suffice it to say that there is a serious and important challenge to move research and development work in Education to include white, coloured and Asian teachers.

This research study was conducted in Soweto and Eldorado Park. These two areas are situated to the West of Johannesburg and under apartheid were designated black and coloured township areas respectively. The study therefore primarily involves black and colored teachers. Two white teachers (who teach at one of the participating schools in Eldorado Park) participated in the project and the research. Stating the race of the researcher in relation to the researched is not commonly found in research relating to mathematics education. However, in critical ethnography it is becoming increasingly important that researchers talk about their own identities (Fine & Weiss, 1998). Apple (2001) in his book *Educating the "right" way*, argues for the importance of focusing on race as it constitutes our 'taken for granted' daily experiences. According to Apple (2001):

> Race is not a stable category. What it means, how it is used, by whom, how it is mobilized in public discourse, and its role in educational and more general social policy - all this is contingent and historical… Race is a construction, a set of fully social relationships… Further, racial dynamics can operate in subtle and powerful ways even when they are not overtly on the minds of the actors involved (p.204).

Other issues of power and ethics in classroom-based research were raised at SAARMSE conferences (Setati, 2000; Vithal, 1998, 2000). Some of these issues are discussed further in

Chapter 4. However the issue of race is as much an issue in INSET as it is in research and therefore I briefly discuss some of these issues here.

During PLESME I became more sensitive to issues of race, gender, power and language. On the whole however I did not intervene directly into the dynamics of how relationships played themselves out. For example, in the early workshops teachers tended to sit with teachers from their own school or a neighbouring school (i.e. with people they knew). This often meant that some groups of teachers were all African, all coloured, all female or all male. Sometimes I (or other presenters) encouraged teachers to sit with teachers they did not know. These patterns changed with time and groupings in workshops became more mixed in terms of constituting teachers from different schools, races and genders.

Initially I was sensitive of my 'outsider' status and the 'power' that my university status gave me. I addressed this by discussing that while I had access to a wide range of resources (for example conferences, department materials, departmental committees, readings, materials, research etc) I was not a teacher and had a lot to learn about what new curriculum ideas meant in practice. I could share my experiences but did not have answers. I could draw on 'experts' but they too did not have answers. We had different strengths to offer and I too was involved in PLESME to learn.

I was concerned that overtly focusing on issues of power and race in the INSET and the research required thorough sociological training, which I did not have. Furthermore I was concerned that such issues could detract from the research. Despite these insecurities, the socio-cultural and social practice framework that I was drawing on compelled me to look at the role 'race' played in PLESME. Thus in August 2000, I put my insecurities aside and conducted interviews with each of the participating teachers (fourteen teachers at that time) to ask them to what extent they saw 'race' as an influencing factor in PLESME. The interviews were unstructured and began as follows:

> I explained that I wanted to understand if there were race issues that permeated the programme. I explained the districts happened almost by accident but that I was happy that it involved racial mixing and mixing of different backgrounds. I explained that being white I can only see these things from a 'white' perspective even though I try and that I need to see other perspectives. I explained that I can be naive to some issues and would appreciate any

> insights for both personal development, professional development, for future programmes and for my research [Interview notes, 1 August 2000].

Of course the information teachers shared with me is shaped by a wide range of factors, not least of which are, that I am white, that I am the co-ordinator of PLESME, that I am a researcher, that I have an established working relationship with the teachers and by what they are able to articulate (i.e. tacit knowledge is often difficult to articulate). In addition, teacher responses are shaped by what is possible to communicate in the 'public domain' in a post-apartheid South Africa. The interviews are therefore located in the PLESME practice and bound by relational factors in PLESME and by broader political and ideological factors.

What is included below is what can and has been expressed within this context and issues dealt with privately remain private. Analysing teacher responses, several key themes emerged. I will deal briefly with each of the key themes. All of the teachers spoke about developing relationships 'across' race, schools or areas. These relationships are important aspects of the community of practice of PLESME and are discussed further in Chapter 6 and 7.

All of the teachers said that they thought that mixing races was good and should be a feature of all INSET projects. Many of the teachers pointed to the realisation that they all had a common interest and that they became aware of how similar teaching issues were irrespective of race or area. The following statement by one of the teachers typifies what teachers were saying in this respect:

> It (mixing different races in PLESME) was a good idea because there are so many different cultures and we can exist in our own cosmos without realising there are other groups doing exactly the same as what we're doing. We have common goals and outcomes. Because of apartheid we never knew what happened on the other side. By bringing together (teachers) from Soweto we realise they are no different from what we are, we share thoughts we might just do things in different ways. We have different cultures and languages and sharing and discussion helps us to overcome these [Barry Interview, August 2000].

Many teachers reflected on the positive relationships that had emerged and that sharing with other areas and racial groups was a positive learning experience:

> This group was one of the most groups I've gained from. I have never worked with coloured teachers. Even their lifestyle to me has been exposed, how they live, how they see things, and how they can integrate with people from different backgrounds. From them we've learnt a lot, the type of communication, teaching. Things are changing and a lot of kids are flocking to their schools and they can in return learn a lot from us. I must not just limit myself to one kind of community. So my scope has been widened. I learnt a lot. It's the first time I have enjoyed my teaching experience and to be associated with people from various backgrounds its not only going to be personal knowledge but I will impart it to my learners as well [Moses Interview, August 2000].

> I have written that the most important aspect of PLESME was the different teachers and the social bonding at AMESA… So it is very positive to bring different backgrounds together, you learn so much. You have to. You can't keep it as an 'Eldos' thing or a 'Soweto' thing. Learners at our schools are from different areas and sometimes we are not sensitive to their culture so this is a learning experience for us [Delia Interview, August 2000].

Thus, while teachers noted difference, they saw the learning enabled by this difference to be positive. The teachers' experience of this difference was however diverse. For example, a teacher noted that two PLESME teachers tended to stick together and not mix a lot with the rest of the group. Other teachers commented on how well they had developed relationships with these same two teachers. One teacher explained that clearly there were differences but that he did not experience these as tensions but rather as 'natural':

> Ivan: I for one haven't operated as seeing them as coloured. The experience has been exciting. We share common things and relate them, things have brought us together. As far as education is concerned, they're also interested in their children…
> In some cases they would say that they have a Soweto learner with a very weak background - but I don't take it bad and I see it from different angles and what they are trying. They have lots of Soweto learners in their schools…
> MG[3]: Any racial tensions?
> Ivan: Tensions no - but differences in perspective - differences yes. Like Cedric lost his brother and funeral arrangements are quite different. I was sorry I couldn't make the funeral -

3 MG refers to myself as researcher.

> so I learnt. Socially they like different things like on the (AMESA) trip - we go to the township, others want to go to town, movies, restaurants. I see this as natural. Not that we disagree we just have different preferences [Ivan Interview, August 2000].

In the interviews I probed teachers to enlighten me on issues of my role in PLESME and whether my race and 'cultural background' had possible adverse effects. In general, teachers responded by saying that they had already spoken about the positive relationships in PLESME and that I was part of this. Some teachers responded using phrases such as 'you have been very professional, impartial and rise above circumstances and differences' [Ivan Interview, August 2000]. Of course since I was conducting the interview it might have been awkward for teachers to express problems relating to how I worked with teachers however I do believe that by the time of the interview I had become less of an outsider to the group and more a part of the group and thus what they were saying about the race issues in the group related to me as well.

In sum, teachers experiences of 'mixing' race groups (and areas) in PLESME (as articulated by teachers in the 'public' domain) was positive. But no one story can be told to illustrate teachers' experiences of race relations in PLESME, these stories differed depending on teachers own histories and the intersection of their gender, race, personal experience and in their words their 'culture.'

I tell the story of teacher learning from my perspective. I will draw on the voices of the teachers as much as possible, but as in any research I do so from my own background. I have engaged in this study with reflexivity as to my race and my position and this reflexivity is bound precisely by that race and position. Indeed one could pay a lot more attention to the racial aspects of PLESME, however, such a focus is beyond the scope of this study. Thus in the words of Adler (2001) 'the story I tell is partial. However, partiality is a feature of all social research, an inescapable reality rather than a necessary weakness' (p.46). As researchers, what is important, is that we engage reflexively with that partiality and as far as possible make it transparent.

6. The dilemma of who participates in PLESME

In many cases 'who' is involved in INSET is prescribed by donors. In general such funding is aimed at previously disadvantaged schools. While the donors of PLESME did not prescribe schools

to work with, the PLESME proposal clearly aimed to support previously disadvantaged communities. The proposal reflected the commitment of the donors, the commitment of RADMASTE centre and my own personal commitment to redressing imbalances in education, currently a priority in South Africa. Part of this redress involves supporting teachers from previously disadvantaged schools to improve their qualifications and to provide them with opportunities for professional development.

Educational redress, however, comes with its own political tensions and unintended consequences. The issue of who benefits from INSET is a double-edged sword. If we restrict INSET to the 'previously disadvantaged,' are we then continuing to work within the apartheid mindset? Are we then colluding with conceptualisations of black teachers as 'deficient'? Does working with previously disadvantaged communities imply that white teachers do not need INSET? On the other hand if we do not redress the inequalities by providing more resources (including human) to previously disadvantaged groups existing inequalities are likely to remain unchanged. Similarly the race of the INSET provider or researcher can be problematised (as discussed in dilemma 5).

In PLESME I chose to work with teachers from previously disadvantaged communities, including schools in black and coloured areas. While both these groups of schools have been disadvantaged under apartheid, the extent of disadvantage was uneven (being far greater for black schools). While I highlight this as a dilemma, I do not believe that there are clear right or wrong decisions to be made in this respect, suffice it to say that it is crucial that all researchers operate with sensitivity, integrity and respect in research and that they consciously reflect on related ethical concerns. Thus who participates in INSET raises dilemmas and while choices need to be made the issues raised by those choices must be articulated and debated.

A second dilemma relating to who is involved in mathematics INSET relates to whether one allows all teachers of mathematics (from participating schools) to participate or whether one recommends a certain level of mathematical competence (or lack of it) so that the INSET intervention can tailor itself to a particular level of competence. This can be compared to debates relating to streaming in classrooms. PLESME, however, wanted to maximise access and form a supportive community of practice among the mathematics teachers from participating schools. Selection of teachers based on mathematical competence or lack of it would be counterproductive to this aim.

At the same time, for participation and engagement to be maximised between teachers, it was important that teachers had a common interest in the mathematics with which they engaged. The compromise decision in this respect was to focus PLESME on a particular phase of education so that while teachers might not have similar mathematical backgrounds they all had an interest in learning mathematics at a particular level since it was the level at which they were teaching. Thus PLESME accepted all senior-phase (grades 7-9) mathematics teachers irrespective of their level of mathematical competence or mathematics teaching experience.

While I believe this was an appropriate decision for PLESME it had implications. In some workshops differences between teachers mathematical competence at solving various mathematical tasks emerged. Mediating mathematical activities therefore required careful consideration and conscious reflection so that those teachers needing basic support were able to obtain it (without feeling demoralised) and those teachers wanting to be challenged to explore the tasks further were encouraged and provided the opportunity to do so.

In summary

Above, I presented six key dilemmas that I confronted and wrestled with in the design and evolution of PLESME. While the dilemmas emerged in PLESME and are exemplified in the case of this project, these dilemmas are in no way limited to PLESME. They are dilemmas that must be confronted in the design of all INSET projects and I believe that the articulation of these dilemmas provide a useful tool for conscious reflection and working practice (Adler, 2001) in the design of INSET projects in general.

The theorisation of these dilemmas provides a contribution to the field of teacher development in South Africa that as explained is in need of research relating to teacher education. It also highlights several practical concerns relating to the third critical question of this research, i.e. what are the implications for a model of INSET based on learning to teach in a community of practice? It is important to note that PLESME develops not only out of a need for mathematics teacher development but in parallel with a need for *research* on models for mathematics teacher development and teacher learning within new INSET practices.

Part 3: Describing the participating teachers and schools in PLESME

Inviting participation

My previous experience of working with schools that were dominated by disruptions and teacher absenteeism was that the opportunity for teacher development was seriously impeded. Furthermore such factors became confounding variables in research relating to the impact of INSET and teacher learning. See Adler & Lerman (in press) for further discussion on the nature of these difficulties in the South African context. I therefore believed that it was necessary to work with schools that were operating relatively smoothly. That is, schools at which teacher attendance was regular and classes generally occurred as expected.

For this reason and for the purposes of developing good relations with districts (by following expected protocol) I requested the assistance of various district advisors to help me identify possible schools where mathematics teachers might be interested and would be likely to benefit from PLESME. Due to my own personal (and RADMASTE's) commitment to working with so-called previously disadvantaged communities and helping to redress education imbalances caused by apartheid I further requested that the schools we approach be 'historically disadvantaged.'

For practical and safety reasons I worked with schools that were reasonably close to the university. This enabled regular support visits to schools and the relative accessibility of the schools (in terms of being close to main roads) provided some reduction in the 'safety-risk' for myself as a white-female travelling regularly to areas in which I was clearly identified as an 'outsider'[4].

In this sense I chose both a purposive and an opportunity target group for PLESME and by implication for the research as well. At the present time in South Africa, for the purposes of INSET or for the purposes of research, it is not conceivable to randomly select schools (Adler, 1996).

4 There are many 'safety issues' as regards travelling in South Africa. I do not wish to imply that these issues are restricted to so-called 'township' areas. However previous personal experience and experiences of colleagues suggests that as an obvious 'outsider' to an area as well as being an outsider with a car and possible resources such as video and television equipment makes one an especially 'attractive' target. While there are no guarantees with any area chosen the district advisor suggested that I work with schools that were relatively accessible to the highway so that it minimised my travel time and made it easier for me to find my way around the area. Despite these precautions an incident did occur at one of the workshops where a group of men came onto the school property and began planning how best to get the television and video that we were using in a workshop. The janitor of the school, noticing this, contacted some of his friends who offered us 'protection' and escorted us off the property. At the time the school had suffered several incidents of armed theft.

Vithal (1998) highlights the importance of working with opportunity samples for research in mathematics education in South Africa. 'Rather than 'telling it like it is', the challenge is to 'tell it as it may become'' (p.480).

I invited the support of district subject advisors from four districts in Gauteng. Three districts responded and offered support. These districts included schools in parts of Eldorado Park, Bosmont and Soweto respectively. Eldorado Park and Bosmont are traditionally urban coloured townships and Soweto is an urban African township. An advantage of these areas was that they were quite close to each other so as to enable joint workshops.

In Curriculum 2005 grades 7, 8 and 9 form the Senior Phase of the GET band. The effect of this in practice is that this phase spans both primary and high school. That is Grade 7 is located in primary schools while Grade 8 and 9 are located in high schools. This means that there is a physical separation between teachers and learners in this phase. For this reason I suggested that we approach schools that are in relatively close proximity to each other and that we also approach the respective high schools that the primary schools feed into. It was hoped that by bringing together teachers from primary and high schools, and of course from neighbouring schools, PLESME would encourage and enable closer collaboration between teachers. I believed that bringing the high schools and primary schools in an area together as well as bringing neighbouring areas with different historical backgrounds together would provide a rich learning environment for PLESME.

In October and November 1998 I went, with the district advisors, to visit various schools in their districts. I met with both principals and teachers and explained what participation in PLESME would involve. I explained that there were funds available for a small honorarium for participating teachers to purchase mathematics resources that they considered useful[5]. I also explained that I wished to collect data on the nature of teacher learning for my doctoral research, for the purposes of improving such INSET programmes in the future and for my own professional development. I explained that teachers did not have to participate in the research and could request at any point that

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5 This honorarium was debated at length with the steering committee of PLESME. It was agreed that this would be a good incentive for teachers and that it would provide a useful way to get teachers to make decisions about what resources are most important given a limited amount of funds. The other side to this discussion was setting up expectations that teacher development should be 'paid'. It was decided that since the money was not for individual teachers but for resources that this should not create too big a problem. I merely note the debate here. For further discussion on this issue in the South African context see Setati (2000).

their ‘data’ be withdrawn from my study. I had summarised various aspects of PLESME into a document and left this for principals and teachers to study before they agreed to participate.

With the exception of the teachers from the Bosmont district and the two Soweto high schools[6], all teachers (and principals) whom we approached expressed interest and enthusiasm for participating in the project.

Who were the participating teachers and schools at the start[7] of PLESME?

At the start of 1999 there were eight schools and seventeen teachers who joined PLESME. All the participating teachers from Soweto are African and their student populations at their schools are almost exclusively African. Eldorado Park is a traditionally coloured area that borders on Soweto. The teachers in these schools are predominantly coloured though there are some white teachers teaching at these schools. The learners in the Eldorado Park schools are coloured and African learners. This population of learners rapidly changed during the two years of the project. According to the PLESME teachers[8], African learners were increasingly attending coloured schools because of the ‘informal settlement’ which was forming nearby and many learners from Soweto were attending Eldorado Park schools due to the perception that these schools were ‘better’ and suffered less disruptions than schools in Soweto.

This impacted on the number of learners in some Soweto schools and resulted in teacher redeployments and retrenchments. Similarly some coloured learners moved from schools in Eldorado Park to schools in neighbouring traditionally white areas. I make a point of including this information because it indicates the transitory nature of these schools in this post-apartheid period. Such changes impact directly on teachers’ daily school environments and indicate a possible area of

6 The district advisor from Bosmont explained that, at a time when the department was heavily retrenching and redeploying teachers and many Bosmont teachers were uncertain as to their jobs for the next year, it would be unlikely that teachers would be willing to put in extra work. Visits to the two suggested Soweto high schools were similarly unfruitful. The principal of one school was unable to find a time to see us and the principal of the other school was away during each visit. In January 1999 we finally met with the principal from the latter school but he was unwilling to allow his teachers to meet with us. We left information relating to the project and requested that he contact us should the mathematics teachers wish to join the project.

7 One teacher left the project after the first two workshops another two teachers from a school left the project after the first term. Their attendance had been irregular in the first term due to sports commitments. I made enquiries at their school in the second term but both teachers were absent from school during this visit. All other teachers remained with the project to the end. One new teacher was accepted onto the project half-way through the first year when a PLESME teacher changed schools and brought her along as his ‘new’ colleague.

tension between Soweto and Eldorado Park schools. The two areas are distinct but due to the movement of learners between the areas schools in the areas began competing for the same student populations.

All of the participating schools had relatively good resources in terms of basic infrastructure (i.e. buildings, toilets, electricity, and core staff). The availability of textbooks and learner materials varied from school to school. In many cases textbooks were not available for learners to take home. In some classes (in each of the schools) overcrowding was evident (that is not every learner had a desk). All schools, except Bakgomana Primary, had a photocopier although access was restricted and its primary function was for the photocopying of examination papers.

Some base-line data about teachers at the start of research

At the start of PLESME I asked participating teachers to fill in questionnaires and conducted individual interviews with teachers. The purpose of this was to get a sense of who the teachers were, their qualifications and experience, their understanding of the new curriculum and their expectations of PLESME. The interviews were recorded and later transcribed. I include a brief summary of this data because it provides useful contextual background for the research that follows.

Academically, of the seventeen teachers, three had degrees with teaching diplomas (though none had majored in mathematics in their degrees), four had 4-year teaching diplomas, four had 3-year teaching diplomas, two had a 2-year teaching certificate, one teacher had a 3-year information technology diploma and one had no post-matric qualifications. The mathematics present in teachers' studies varied. The majority of teachers had never studied post school mathematics although twelve of the teachers had studied mathematics at matric level. The implication of this data is that, as discussed above, very few teachers had actively chosen to become mathematics teachers and therefore few had actively pursued studies toward this. For most teachers their role as a mathematics teacher happened 'by accident.'

8 This information was obtained in a workshop discussion with PLESME teachers. It is reflected in my journal of 20th August 1999.

In interviews, teachers were asked whom they talked to about mathematics education and about the nature of that talk. Teachers indicated that discussions with district officials usually involved 'administrative talk,' for example they would be given the sequencing of mathematical content, dates for common assessments, dates for teacher evaluation etc. This 'official' support from districts can be described as 'administrative surrogates' (Thompson & Holloway, 1997), which refers to 'a contrived form of collegiality' (p.312), as a substitute for more genuinely collaborative teacher cultures.

They also described their talk within their maths department as largely administrative relating to dates for exams, dates for marks, content of examinations and reports etc. Such meetings were infrequent (usually one per quarter). On the other hand they described their (informal) discussions with friends/spouses and colleagues as relating more specifically education in general and to difficulties in teaching mathematics, problem children and ideas on teaching. For some of the teachers their spouses or immediate family were also involved in teaching and thus provided an opportunity for regular engagement about education.

In terms of teacher feelings about the 'new curriculum' responses could be categorised as positive, negative, insecure and ambivalent. The most frequent response was that of insecurity. Positive and negative responses were almost equal and many teachers expressed a mixture of these responses. In terms of information teachers had concerning Curriculum 2005 typical responses were 'very little', 'not much information', 'nothing' [Questionnaires, January 1999]. While some teachers had heard about Curriculum 2005 from friends, colleagues and the media, on the whole, teachers were very poorly informed and had received no Curriculum 2005 documentation.

Part 4: Describing the nature of PLESME (the practice and activities)

I have outlined the influences on various design features of PLESME. I have revealed that some underlying assumptions of PLESME were that teacher learning would be best enabled by long-term, small-scale, classroom-focused, community of practice-based INSET in which reflective practice, networking within the broader profession and focusing on developing deeper mathematical and mathematical pedagogical knowledge were central.

In this part of the chapter I first describe some of the external factors that influenced the PLESME practice and then describe the practice. It is important to note that the PLESME practice was not static but constantly evolving in response to changing relations between participants, presenters, myself as co-ordinator, communities, schools, other members of the mathematics education profession and external factors relating to education and schools in general.

The influence of external factors, relating to education in general, on PLESME

As discussed in Chapter 1, PLESME operated at a time of rapid change. From reflection and analysis of journal entries I identified three contextual factors, which were repeatedly recorded as having an effect on PLESME. These were the public service strikes over salaries and working conditions, the NDE's repeated indecision about whether to go ahead with Curriculum 2005 and the focus, post 1999, by the new minister of education on 'performance' in schools.

This is not to negate the many other factors impacting on teachers' lives in different ways and which therefore also affected the PLESME practice. Rather the factors described were the most 'identifiable' in terms of influencing the discussions and the nature and ethos of PLESME. I discuss these factors briefly.

The effect of the public strikes:

In August 1999 nation-wide public service negotiations and strikes begin. The South African Democratic Teachers Union participated in the strikes. The schools in Soweto were severely affected by these strikes for most of August 1999 while the schools in Eldorado Park were relatively unaffected. The effect of the strikes on PLESME was a loss of momentum due to cancelled workshops and an effect on teacher morale [Journal, 3 September 1999]. These strikes had a significant effect on teacher morale largely because they added to the stress relating to confusion around Curriculum 2005.

The effect of the NDE's indecision as to the implementation of Curriculum 2005:

From the start of PLESME it was unclear whether Curriculum 2005 would be implemented at Grade 7 level in January 1999. Curriculum 2005 was due to be implemented initially in 1997 but

had been repeatedly postponed due to a range of implementation problems. Furthermore there was much bad press relating to the value of OBE and its reported failure in various countries (see for example Jansen 1997 in *The Star*). In January 1999 it was announced that the NDE would not be implementing Curriculum 2005 that year and that it would be postponed till the next year. Towards the end of 1999 it was still unclear whether Curriculum 2005 would be implemented in 2000. In a journal entry of 16th September 1999 I wrote:

> It is still not clear whether the new curriculum will or won't be implemented at Grade 7 level next year…. This up in the air is driving everyone in education crazy. What a crazy field to work in frantically preparing, books, policies, courses, workshops etc for implementation, which is constantly postponed. The demoralisation of department workers, non-government organisation workers, etc is all part of the broader education sphere, which is demoralised. All of this will have an impact on teacher morale. Solution??? [Journal, 16 September 1999]

The combination of the strikes and the indecision relating to curriculum change clearly affected the morale of teachers. PLESME needed to adapt in order to accommodate this. At a PLESME workshop on the 8th September 2000 teachers raised their frustrations as to the indecision relating to the implementation of Curriculum 2005. One of the teachers summarised the feelings of the group as being '*gat vol*[9].' My response to this was to postpone the planned workshop for that day and to replace it with a discussion session on what and how teachers were feeling about this and also about how best PLESME should respond to this. The discussion was used as the basis from which to modify and plan future workshops for the rest of the year. In my journal entry of the 10th September I reflected on this discussion.

> At the workshop on Wednesday Elaine said that she had read an article in which Kader Asmal said that Curriculum 2005 would not be implemented at Grade 7 level next year since there was no money available for this. I used this to open up a discussion with teachers about what they thought of this in general and in terms of PLESME. We discussed that PLESME was more broadly focussed than just on the new curriculum and that the work was still relevant. It did open up however some negative emotions around teachers' feelings towards the department. Barry explained that he was tired. Other teachers resisted this and argued against him when they saw it as a possible criticism of PLESME. I felt however that

9 A South Africanism which means one has had all one can take.

> the enthusiasm of teachers in PLESME had lowered not so much about PLESME but just general teacher enthusiasm and energy. All the teachers seem really tired… Other teachers expressed concerns about the implementation of C2005. Kurt asked 'if they don't have the money for next year when will they have it?' He also emphasised that his learning was still relevant and it did not matter if they did not implement next year. The ethos of the discussion was for me positive in the sense that teachers were talking with a common feeling, 'we're all tired, we can express this in PLESME and not against PLESME.' Even I, Mellony, am tired. In a sense it was a good acknowledgement for all of us [Journal, 10 September 1999].

The effect of this 'external factor' was not only to affect the morale of PLESME but also to change the PLESME practice to 'formally' include informal discussions about teacher feelings. That is, for the first time in PLESME workshops, an entire workshop was devoted to how teachers felt, their frustrations and their fears. This alone was the focus of the workshop session, there was no planned content and there was no planned outcome of such discussions. As the co-ordinator my response in general was to acknowledge that teachers were working at a very difficult time in their profession and I too was frustrated by the indecision around Curriculum 2005. I wished the teachers 'strength' and offered support in terms of a sympathetic ear rather than offering any answers or coping mechanism. Teachers drew on each other for support as to these difficulties and seemed to draw strength from sharing frustrations and the realisation that we were all in the same boat in turbulent waters.

Following this discussion I redesigned the PLESME programme of workshops for the fourth term so as to reduce the number of workshops and to focus on issues that did not relate directly to Curriculum 2005. For example, we held a workshop where teachers shared ideas for the end of year examinations. I included a fieldtrip to a number of education organisations and this had the effect of providing teachers time to meet outside of the school and workshop environment and to get to know each other better through spending a whole day together.

Thus, an unexpected outcome of discussions relating to this 'external factor' was that the release of frustration led to a re-design of PLESME and the re-emergence of PLESME enthusiasm. By the next term participation was back in full swing and the usual PLESME 'vibe' had returned.

> Had a great workshop with teachers today, great in the sense of vibe, watching teachers share and getting a sense that really good working relationships and friendships are forming [Journal, 6 October 1999].

Finally, in January 2000, it was announced that Curriculum 2005 would be implemented at Grade 7 level that year.

The effect of an emphasis on performance:

In Chapter 2 I discussed the tensions created by the outgoing performance based curriculum and the incoming competence based model (as embodied in Curriculum 2005). All of the PLESME teachers expressed concerns about these tensions. Teachers repeatedly questioned whether they should be implementing the new curriculum or whether they should be continuing with the 'old' curriculum, still examined at the matric level. The focus on 'performance' by district officials mirrored the general focus on performance that was emerging in the press. This tension particularly affected teachers from Soweto schools.

Teachers in schools in Soweto were compelled to write common assessments obtained from their districts. The PLESME teachers felt that their professionalism was undermined and were confused by the contradictory messages they were receiving (discussed in Chapter 2 above). Should they implement new curriculum ideas or continue to teach according to the 'old' curriculum in order to perform well in external assessments.

There were no such common assessments in the primary schools in Eldorado Park, however 'district visits' to some Eldorado Park schools were seen as inspections. Again the teachers from Eldorado Park were confused as to whether to show their success at improving learner performance on 'traditional type' tests or whether to demonstrate their efforts at working with new curriculum contents and methodologies.

The result of these contradictions and tensions affected the morale of teachers. The primary response of PLESME in relation to these factors was again to provide a forum for discussion and airing frustrations. Such tensions would become central points of discussion in workshops and

teachers would discuss ways to ‘cope’ with the situation. Teachers found ‘comfort’ and strength in voicing their frustrations and seeing that they were ‘not alone’.

The timeline in Appendix 3 illustrates the activities of PLESME in parallel with the influences of the ‘external factors’ reflecting the relationship between the two.

Acknowledgement of tensions relating to the teaching of mathematics education and frustrations relating to broader education influences and raising them as valuable topics for discussion thus became important in the practice of PLESME for the next year.

The changing nature of the PLESME practice and its activities

In the PLESME document given to teachers at the start of the programme (October 1998) it was stated that the programme would include:

- Weekly workshops
- Individual and group reflection sessions
- Classroom visits and the use of video to facilitate reflection and discussion
- Individual and collaborative practical assignments to be done in school
- Some written assignments to accompany practical assignments.

I have described above how, with time, other practices and activities emerged as important PLESME features. For example, the practice of teachers sharing frustrations and the inclusion of activities in which teachers were networked into the broader professional community of mathematics educators. The activity of networking teachers within the broader profession of mathematics education indicated the emergence of a new assumption as to how best to maximise teacher learning. That is that in order to maximise teacher learning I should provide the PLESME teachers access to other mathematics education communities of practice.

I thus decided to build networking teachers with other educators in the field of maths education into the project. I organised fieldtrips to various teacher centres, to district offices and to the RADMASTE, AMESA and GICD offices. I also arranged for the PLESME group to attend the AMESA national conference in Bloemfontein and we worked together to each prepare a

presentation. My aims were to enhance participation of teachers in these communities. Thus my concept of 'communities of practice' was extended to see 'professional networks' (Wilson & Berne, 1999) as a very important overlapping community to the PLESME community.

Furthermore, with time, I began to see PLESME teacher participation in such professional networks as a means of sustainability of teacher involvement after PLESME ceased to exist. Towards the end of PLESME, the teachers launched a 'SOWELDO' branch of AMESA, ran workshops for teachers in their area under this banner and committed themselves to continuing to organise activities for teacher in their area with the support of AMESA.

This 'professional networking' was not restricted to participation in the professional association of AMESA. In addition PLESME networked teachers with various people from education related organisations and worked collaboratively (as the PLESME group) to provide input into curriculum documents such as GICD progress maps, the Report of the Review Committee and on producing a booklet *Maths in Newspapers*. These developments in PLESME are indicative of my increasing awareness of the importance of teachers inputting actively into broader communities rather than passively receiving information from them.

In the December 2000 report to donors I emphasised a range of 'new' aspects that had emerged in PLESME (i.e. they were not emphasised in the initial proposal). Namely that PLESME would:

- coordinate a range of dynamic and highly motivated educators to work with teachers in workshops;
- constantly encourage teachers to reflect on their practice and find ways of working with new ideas - it will not prescribe 'recipes' for teaching;
- obtain its direction from the participating teachers, according to the changing needs of its teachers and reflect on its own practice through journals, questionnaires, interviews and other means;
- take cognisance of the wide range of experiences and knowledge which teachers bring to the programme and draw on this as a resource. Teachers are professionals and PLESME is part of teachers' life long learning and professional development;
- assist teachers to network with a wide range of other 'communities of practice' relating to mathematics education;

- view learning as a two-way process between PLESME presenters and PLESME teachers;
- continue after certification and after funding has come to an end; and
- find ways for teachers to share their knowledge, experiences and enthusiasm with other teachers in their communities and beyond their communities [PLESME report to donors, December 2000].

The statement in the 4th bullet that teachers are professionals and that PLESME is part of teachers' life long learning and professional development is illustrative of the shift from 'teacher change' to teacher learning that I discussed in the dilemma of ethos above. Teachers clearly appreciated the view that they were professionals and part of the broader community of mathematics educators. For example one teacher wrote:

> Never did the presenters make us feel that we were not qualified mathematics teachers. We had a lot of encouragement and compliments… PLESME programme also allowed us to move out of the class – to interact socially – meet other stakeholders involved in education [Beatrice Questionnaire, July 2000].

> Reflective practice was seen as an important part of PLESME both for teachers in relation to improving their teaching practice and for myself in relation to improving the PLESME practice. There is much literature supporting the importance of reflective practice[10] for stimulating mathematics teacher learning both locally (Adler & Reed, in press; MEP, 1997; Rossouw & Smith, 2001) and internationally (Schon, 1983; Jaworski, 1994; Cobb, 1997).

The notion of reflective practice was incorporated into PLESME in workshops and teacher classrooms. In one of the first PLESME workshops, a presenter explained the concept of action-reflection for professional practice. In this workshop the notion of reflection that was used was action-oriented where its product is praxis (informed committed action) (Kemmis, 1985). Teachers were provided with a range of resources relating to reflective practice and 'action-reflection'. For example, reflective writings of teachers involved in INSET (for example, Agherdien, 1997) and

10 Reflective practice is also encouraged in Curriculum 2005. In the Manual for the Developmental Appraisal for Educators (undated) reflective practice is listed as the first of five ongoing processes which are considered for appraisal. These are reflective practice; self-appraisal; peer appraisal; collaboration and interaction within panels.

‘action-reflection’ templates with some ideas to support teachers in their reflection (see Appendix 4) were provided to teachers. A video recorder and ‘teach-master’ was also used to support ‘stimulated recall’ and reflective practice. Reflective practice permeated PLESME and was indeed part of my work as an INSET co-ordinator. This reflective practice influenced the changing nature of PLESME.

The timeline in Appendix 3 illustrates the changing nature of PLESME activities over the two-year period. In the first year workshops primarily involved presentations by ‘guest speakers’ on a range of mathematics content areas and a range of topics relating to new forms of methodology. In the second year workshops became more teacher-driven. That is in many workshops teachers took the lead to present ideas, teachers chose topics for discussion in workshops, teachers shared resources and ideas they had found at the start of each workshop etc.

Research papers are included in the time-line to illustrate the integrated and ongoing relationship between PLESME and the research. This is discussed in more detail in Chapter 4.

In summary:

In this chapter I have provided some description and analysis of the empirical field of the research, PLESME. I have described its evolution in terms of the confrontation of several dilemmas ranging from practical and ethical decisions involving who, what, where and when, to issues relating to the content and nature of the INSET. I have provided some description of the PLESME practice, a timeline of its activities, external factors that influenced PLESME and a brief description of the teachers who were involved in PLESME at the start of the project.

In the next chapter I focus on the research methodology that I used for this study. That is, I discuss how I attempted to systematically study teachers’ learning in PLESME. My role as co-ordinator in PLESME (as emphasised in this chapter) is therefore de-emphasised and my role as researcher in PLESME is emphasised.

Chapter 4: Researching teacher learning: design, methods and issues

As noted in Chapter 3, this research study is intertwined with PLESME. In Chapter 3, I focused on issues relating to the design of INSET. In this chapter I focus on methodological issues relating to conducting research in education and, more specifically, at issues relating to conducting research on mathematics teacher learning during INSET in a post-apartheid South Africa. This chapter includes the following:

Part 1: The Research Methods.
In this section I explain the various research methods used for the study and explain why I chose these methods. I include a discussion of the influence of PLESME on issues such as containing the research sample and other research processes.

Part 2: Ethics and the Research Process.
Ethical issues are embedded in any research. In this section I explore some of the ethical issues embedded in this research study, and relate these to both the South African context and to broader ethical debates in interpretive research.

Part 3: The Process of Data Analysis.
Data analysis in qualitative research can be a very difficult process even when the amount of data to be analysed is small. This difficulty is compounded for large amounts of data. In this section I unpack the process of data analysis as it unfolded in the study and explain the range of data analysis techniques that I drew on.

Part 4: Trustworthiness: Reliability and Validity.
In this section I explore how the study addressed issues of trustworthiness. In particular I examine notions of reliability and validity. I relate these notions to the study and to broader debates in the field of interpretive qualitative research.

Part 5: Generalisability, Generativity and Exemplarity.
Generalisability needs to be carefully interrogated in terms of its relevance and achievability in qualitative interpretive research. Drawing on the work of several writers I re-examine the meaning

of generalisability for interpretive research and for the purposes of this research study and supplement it with notions of generativity and exemplarity.

Part 1: The Research Methods

In this study I have drawn on a wide range of qualitative research methods. These methods include: interviews, questionnaires, classroom observations, video recordings of teacher lessons, participant observation and field notes. While I read a wide range of literature relating to different types of qualitative research methodologies such as field study, ethnographic research, interpretive research, case study research, grounded research and action research, no one 'label' worked entirely and I found it useful to draw on different aspects of each of these for the study. Indeed the distinctions between these methodologies are blurred and Merriam (1998) notes that these terms are often used interchangeably.

In this study the research methods used were informed by the above qualitative research paradigms. In addition to being influenced by these research paradigms the methods I used emerged out of my prior experience of research in teacher education, my knowledge of the context in which the research was being conducted, my relationship with the teachers which was developing in PLESME and my views of what was possible to expect of teachers given their time constraints. The choice of methods and instruments was therefore theoretically informed, practical and responsive. In this section I will explain each of the research methods (instruments) used. I have referred to qualitative methods as if they were taken for granted as the only possible choice for this research. Indeed they were, but let me begin with a brief prelude to justify this assumption.

Why qualitative research?

In the rationale (see Chapter 1) I explained the need for long term studies that take into account the wide range of contextual factors which impact on teachers and thus on teacher learning. This is especially important in the South African context where complex social, political and economic issues ramify into education interventions and individual teacher learning.

Much research that draws on quantitative methods 'backgrounds' complex contextual factors and often produces discourses of teacher 'failure' and 'deficit.' The interpretation of the results of South

Africa's performance in the TIMSS study, that placed South African learners at the bottom of the pile, is one such example. These results hide various contextual factors and have produced a discourse of deficit (see Adler & Lerman, in press; Keitel & Kilpatrick, 1999). I do not wish to imply that qualitative research methods do not contribute to the production of 'deficit' discourses, or that all quantitative research studies background contextual factors, but rather that a critical approach to qualitative research that foregrounds contextual factors is a means to moving away from the production of 'deficit' discourses.

Hitchcock & Hughes (1995) support the choice of a qualitative approach in the context of educational research:

> It has been our view for some time that the processes of education, teaching and learning are so complex and multifaceted that to focus only upon cause and effect, products, outcomes or correlations in research on schools is of limited value. The complexity of education demands the use of many different research techniques and models. The most productive approach we believe is a qualitative one (p.25).

This study is *not* an impact study of PLESME, nor is it interested in focusing on cause and effect in terms of some predefined set of expected outcomes. Instead it examines the *nature* of teacher *learning* within the PLESME community of practice and in the context of curriculum change in South Africa. Such a process is not easily or usefully quantified and quantification at the expense of a rich understanding of these factors would be ethically problematic.

Many writers have traced the philosophical roots of qualitative research to phenomenology while quantitative research is more commonly[1] linked to positivism (Merriam, 1998). Positivism assumes that a social reality exists independently of the observer. The choice of qualitative research for this study coheres with various philosophical, epistemological and ontological assumptions inherent in this research, in PLESME, and in the chosen theoretical framework.

At the basis of my choice of qualitative methods are the assumptions that: reality is constructed by individuals interacting in their social worlds and that meaning is embedded in individuals

[1] I emphasise, 'more commonly' as there are many researchers who use quantitative methods in ways that are not positivist.

experiences and is mediated by the researcher's perceptions (Merriam, 1998) and that knowledge is both personal and social (Lave & Wenger, 1991; Wenger, 1998). This should not imply that I believe that as a researcher I am free to interpret at will. Rather, I believe that while the social world is mediated by the researchers' experiences, these experiences are still subject to issues of rigor, trustworthiness and validity.

I have argued that the methodology chosen coheres with the theoretical framework of social practice theory and the work of Lave & Wenger (1991) and Wenger (1998). This requires further elaboration. In their terms, data collection would need to include teachers talking about (and within) their practices. That is, data must include what teachers said and what they did. To access such data would involve close interaction between the teachers and myself (as researcher), and would require good relations of trust and mutual respect.

In light of this, I chose to become a 'participant observer' in the PLESME practice, where my participation was as the coordinator of the practice, but still clearly part of the community of practice and I became an 'observer participant'[2] in teachers' classrooms. Of course my role as coordinator of PLESME (in addition to being the researcher) and the changing dynamics in PLESME over time add particular dimensions to the stance of participant observation and observer participant as I have discussed in Chapter 3.

Merriam (1998) notes several characteristics common to all forms of qualitative research. These include: the researcher is the primary instrument for data collection and analysis; it usually involves fieldwork; it primarily employs an inductive research strategy; typically research findings are in the form of themes, categories, typologies, concepts, tentative hypotheses and theory, and as importantly, the research product is richly descriptive. He adds that the design is flexible and emergent and that sample selection is usually non-random, purposeful and small. Each of the above is a characteristic of this research study.

[2] Merriam (1998) distinguishes between four possible stances an observer can take in relation to the observed. These are complete participant, participant as observer, observer as participant and complete observer. In the participant as observer stance, the observer's activities are well known to all and are subordinate to the researchers role as participant. This indeed was the case in my role in PLESME. In the observer as participant stance, observer activities are known to all and take precedence above participation. Complete participant involves concealing ones observer role and complete observer involves the researcher being hidden. Both of these would be ethically problematic and inappropriate for this study.

Before looking at the different methods used, it is important that, in relation to my being the most important research instrument, the research process is fully described and itself becomes the object of study (Adler, 1996). Reflexivity on the part of the researcher is an essential element of qualitative research, not only because it supports the opportunity for the 'transformation in the being of the researcher,' which is the most significant product of research (Mason, 1998, p.357), but also because it provides transparency from which the validity of the study can be interrogated and established.

For this reason I have in Chapter 3 made the relationship between PLESME and the research a direct object of the study. However, highlighting the reflexivity of the researcher in the study is a double-edged sword: without reflexivity the validity of the study cannot be established, but highlighting this reflexivity has the effect of privileging the voice of the researcher.

Another important aspect in relation to my being the most important research instrument is the relationship between myself and the 'researched' (see Part 2 below). This brings into focus the researcher's 'way of being.' It is difficult to explain one's own 'way of being' (Lave and Wenger, 1991) as an important factor in the research. In some sense it could be compared to explaining, in psychological terms, the effect of a researcher's personality on a research study. While this is difficult, I do believe that my 'way of being' played a large part in the nature of the relationships that developed in PLESME, and in the willingness of participants to give of their time freely to research related questions and to engage with these with enthusiasm. Therefore I believe it is important that I briefly describe the nature of PLESME relationships that inevitably shaped both PLESME and the research.

The importance of my own role in affecting relationships in PLESME was highlighted in teacher questionnaires. For example, one teacher wrote, 'It is because of you Mellony that we are so close' [Rosina Questionnaire, June 2000]. In my journal I regularly wrote about the PLESME 'vibe' which I used to describe the enthusiasm, friendliness and jovial atmosphere in many workshops. As the coordinator of PLESME an important role was maintaining this 'vibe,' reflecting on times when the 'vibe' was low and finding ways, and structuring activities, to rekindle it (see Chapter 3 above). Cohen & Manion (1994) note the importance of 'setting the right tone' for research and I believe this relates to what I refer to as maintaining the 'vibe'.

The PLESME 'vibe' was unexpected. While I had developed good relations with teachers in previous INSET projects, I had never felt that there was as much enthusiasm, commitment and mutual respect as I experienced in PLESME. I attribute this largely to the commitment of the teachers, the longer-term nature of the project and my ongoing reflection on the 'ethos of PLESME' as an important feature of the project. I have discussed some of this in Chapter 3. It is evident from questionnaires and interviews that good professional, and to some extent personal[3] relationships, were developed both between teachers in PLESME and between myself and teachers. In sum, relationships were characterized by sincerity, care, trust and motivation on both the part of the teachers and myself as PLESME coordinator and researcher.

In the next section I describe the various methods used in the research study. These methods were mutually developmental in the sense that each data source influenced the next process of data collection. I begin with the issue of sampling.

Sampling

In Chapter 3 I described how PLESME came to be the empirical field for this study and the way in which data collection processes, such as interviews, videos, journals etc., were as much a part of PLESME as a part of the research. I have explained how, due to various factors, the teachers in this research study came to be senior-phase mathematics teachers in Eldorado Park and Soweto.

Early on in the research I had to confront how to select a manageable 'sample' of teachers from the PLESME group for the study. With time however it became clear that this was ethically not possible. Clearly teachers valued their time during interviews as an opportunity to express how they were feeling about PLESME,[4] about education, about mathematics teaching in general and about their work in their classroom. Teachers wanted to share what they had been doing in their classes and share their positive experiences (and frustrations) of 'trying out' new ideas.

[3] Personal in the sense of my involvement in PLESME sometimes discussing personal issues with teachers, sharing in celebrations (e.g. a wedding), meeting with teachers for lunch in a teacher's home etc.
[4] This was clear from teachers willingness to give up their time for the interview and their extension of interview time beyond what was allocated. Interview questions served as the prompts for teachers to discuss a wide range of issues that they were wanting to articulate. In many cases questions were answered in terms of the teachers own agendas of what s/he wanted to discuss. This reciprocal relationship is discussed in more detail in the next section on ethics.

Furthermore selecting teachers would inevitably involve excluding others. Such a process would likely change the relationships in PLESME and would create division between those involved in the research and those who were not. For these reasons, I felt it not possible to exclude any PLESME teacher from 'research related' activities. Thus despite the enormous time involved in collecting qualitative data on fourteen[5] teachers over a two-year period, I proceeded to collect data on all participating PLESME teachers.

There were research gains and losses related to this decision. My experience of disruptions in schools and projects meant that I had learnt to err on the side of over collecting rather than under collecting data. Much research in South Africa is affected by disruptions that make it difficult to answer the research questions one sets out to study (see Vithal, 1998; Adler & Lerman, in press; Nyabanyaba, 2001). These disruptions can possibly include strikes, teacher absenteeism, funerals, sports arrangements, examinations, timetable rescheduling etc. Having a larger research sample would allow for various disruptions without necessarily having to change the research question or the nature of the data gathering techniques.

This said, I fortunately experienced very few 'disruptions' relating to the data collection (resulting in extensive data sets for fourteen teachers in PLESME). Disruptions to PLESME occurred during the strike period (see Chapter 3) but since PLESME was a two-year project it did not weigh heavily on the research. It simply involved rescheduling classroom observations and video recordings for later in the year than planned. Other minor disruptions occurred resulting in rescheduling occasional classroom visits or interviews.

The absence of major disruptions meant that rich sets of data were collected on all of the participating PLESME teachers providing both breadth and depth to the research. On the one hand collecting data on all the teachers provided a wide range of data to inform the research and from which to select case studies. On the other hand, the volume of data generated meant that the data became difficult to manage and analyse. In order to deal with this tension I worked with all the data for certain aspects of the study and focused in on 'case studies' of teachers when in depth individual analysis was required. I discuss this tension in the section on data analysis below. The

[5] Four teachers withdrew in the first three months and one teacher joined after the first 6 months. This is discussed shortly.

key point to note is that for these reasons the sample for the general study[6] was all participating PLESME teachers.

Another advantage to keeping all participating PLESME teachers in the general sample relates to the theoretical framework of the study. In relation to Lave & Wenger's (1991) and Wenger's (1998) theory of learning in communities of practice, it is necessary to see the individual teacher in relation to PLESME and also to see PLESME in relation to the individual teachers who constitute it. Collecting data on all teachers enabled the unit of analysis for the study to be *both* the teacher and the PLESME community of practice, viewed in dynamic relation to each other. That is the unit of analysis was both the *teacher in PLESME* and *PLESME in the teacher*, or as Slominsky[7] so succinctly put it - *the teacher*-in-*PLESME*-in-*the teacher*.

In other words, to explain individual teacher learning in PLESME requires an understanding of teachers' participation in the PLESME community of practice (constituted by all the teachers and myself). And to explain the nature of the PLESME community of practice, the study requires an understanding of PLESME's influence on individual participants. Including all members of PLESME in the research sample therefore opened up many options for data analysis that would otherwise have been closed had I pre-selected teachers at the start of the research.

Thus, the sample can be described as a small, purposive, opportunity sample in the sense that PLESME teachers were not randomly selected but were volunteers from schools suggested by the districts. The teachers are not typical of the general population of mathematics teachers. They are from urban township schools and are clearly dedicated teachers as evidenced by their willingness to contribute a large amount of their time and energy in order to participate fully in PLESME. The teachers showed great commitment to learning more about mathematics education and to improving their practice. Descriptions of teachers in terms of their academic, professional and motivational features are given in Chapter 3.

While the sample for this study is "all teachers who participated in PLESME", it must be pointed out that those teachers who withdrew from PLESME for various reasons inevitably 'dropped out'

[6] The general study draws on all fourteen teachers while in Chapter 7 I focus on ten teachers for more in-depth analysis.
[7] Steve Lerman, a guest of our reading group, has recently discussed this concept in relation to Slominsky's idea of mind in society in mind (an extension of Vygotsky's Mind in Society), see Lerman (2000). Put in such a way the

of the sample. Within the first six months four teachers withdrew from PLESME. The primary reason given was difficulties relating to the time commitment involved. The significance of this is that these withdrawals impacted on the sample for the research. It was not possible to collect data on the teachers who withdrew other than to establish the reasons why they withdrew[8].

These withdrawals create what I call a 'double' opportunity sample in the sense that two selection processes (of necessity) took place. First, the selection of teachers for PLESME and, secondly, the selection of teachers, from those who continued to participate in PLESME, for the study. While it is important to make this point, I do not believe that this is problematic or unusual for a study of this nature. While the 'time factor' was an issue for all PLESME teachers the remaining teachers were able to negotiate[9], with their schools, that Wednesday afternoons were dedicated to PLESME (thus PLESME took priority over other activities that might have been scheduled on a Wednesday afternoon).

In addition to withdrawals, there was an addition to PLESME. In August 1999 a teacher, who had changed schools in order to take up a head of department position at another school, brought his new colleague to join him. Within a few sessions she became integrated into PLESME and participated in both general and group discussions. This teacher forms part of the data sample in that she participated in questionnaires, video sessions and interviews. Another teacher who changed schools brought a colleague along later in the programme (March 2000)[10]. She attended approximately four to five workshops but never became fully integrated. While participating during sessions, she never participated in fieldtrips, the conference, video sessions, interviews or questionnaires. She thus does not form part of the data sample, except in relation to the PLESME community of practice as reflected in journal entries.

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dialectical relationship between 'mind' and 'society' is foregrounded rather than focusing on one at the expense of the other.

[8] Two of the teachers had sports commitments on Wednesdays that interfered with PLESME workshops. (They withdrew after three months). One teacher withdrew after the first three workshops. Later it emerged [Karl Interview, June 1999] that he did not see himself being a teacher for long and therefore did not want to commit the time. He was surprised by the commitment of his colleague and asked 'Do you want to be a teacher your whole life?' The fourth teacher arranged a meeting with me to explain his reasons for withdrawing from PLESME. He explained that due to poor performance in matric mathematics results at his school and the pressure from parents and the department to improve results, he had been requested by the principal and the head of department to give extra mathematics lessons everyday after school. This in addition to a full teaching load (he did not have a single free period during the week) and many sports commitments. He regretted withdrawing and said he hoped to rejoin if his situation improved.

[9] This ability to negotiate PLESME time, as a priority, was supported by the initial meetings held between myself, district workers and principals and our success at getting most principals 'on board.' The honorarium available to schools for participating teachers to purchase resources undoubtedly also helped in this respect.

However, there was some later selection from the original sample. After detailed analysis of all data gathered on participating teachers, I selected ten teachers on which to conduct further analysis in the pursuit of explaining teacher learning in the context of PLESME and the current curriculum change. The justification for the selection of these teachers is given Part 4 of this chapter.

A wide range of data was collected from all participating teachers except where circumstances prevented a teacher being involved. The table below provides a summary of the types of data collected, the nature of the instrument, the period when the data was collected and the number of teachers involved.

Table 4.1: A summary of data collected

Type of data	**Nature of instrument**	**Period collected**	**Teachers involved**
Coordinator and researcher's reflective journal	Informal writings after interactions with teachers and other times.	Aug 98 – Nov 00	NA
Interview	Structured interview, approximately 10 - 20 minutes Tape recorded and notes taken. Later transcribed.	Feb 99	All, except two, PLESME teachers (due to time problems)
Basic information questionnaire	Structured, paragraph form, relating to base-line data.	Jan 99	All teachers
Classroom practice videos and observation Reflection on videos	Structured observation schedule used to assist reflection discussion which followed with teachers. Videos taken by myself, focusing primarily on teachers but also learners when they were speaking or engaged in activities. Usually a double lesson (about 50 – 70 minutes)	Feb 99	All PLESME teachers except two [11]

[10] The new teacher was the wife of one of the participating PLESME teachers and good friends with some of the PLESME teachers who lived in her community.
[11] These teachers requested to not be video recorded and later left PLESME.

Interview	Structured Detailed notes taken and tape recorded. Selective transcriptions 20-40 minutes	Jun-Jul 99	All 13 remaining teachers
Networking diagrams	Structured diagrammatic tool for getting teachers to represent the various people and communities that they engage with on mathematics education. Activity took about 40 minutes.	Sept 99	All 13 remaining teachers
Classroom practice videos and observation Reflection on videos	Structured observation schedule used to assist reflection discussion which followed with teachers. Videos taken by myself, focusing primarily on teachers but also learners when they were speaking or engaged in activities. Usually a double lesson (about 50 – 70 minutes)	Oct 99	All 14 participating PLESME teachers (one additional teacher joined)
End of year 99 questionnaire	Paragraph form questionnaire	Nov 99	All 14 participating PLESME teachers
Classroom practice videos and observation Reflection on videos	Structured observation schedule used to assist reflection discussion which followed with teachers. Videos taken by myself, focusing primarily on teachers but also learners when they were speaking or engaged in activities. Two to three consecutive lessons over a two-day period. Usually (about 70 – 100 minutes in total)	May 00	All 14 participating PLESME teachers
End of workshops questionnaire	Paragraph form questionnaire	July 00	All 14 participating PLESME teachers

Interview on understanding race in PLESME	Unstructured, open discussion, probes on race. About 5-10 minutes. Detailed notes and tape recordings. Transcribed where used in research study.	August 00	All 14 participating PLESME teachers
End of PLESME interview	Structured Approximately 20 – 40 minutes	Nov 00	All 14 participating PLESME teachers
Other data sources	Odds and ends such as worksheets teachers provided to us at workshops, proposals, assignments, conference presentations and videos of some of the workshops.	Feb 99 – Nov 00	All 14 participating PLESME teachers

Below I provide an explanation for the various data sources.

My journal [12]

From the start of PLESME I kept a journal that I wrote in regularly (at least on a weekly basis). This journal served four purposes. First, it served to summarise field notes taken during workshops or immediately after interactions with teachers. In this sense I took the position of 'participant as observer' (Merriam, 1998, p.101) in the PLESME practice. That is my primary role was to participate in PLESME as coordinator but I was also an observer taking notes and recording, in my journal, observations for the purposes of the research. Secondly, it served as a reflective device to analyse what was happening in PLESME and to make suggestions on how to modify it. In this sense it enabled a type of action-reflection cycle that greatly influenced the nature of PLESME. Thirdly, it served to consolidate and record research ideas that emerged out of reflections on PLESME and discussions I had in supervisory sessions, doctoral presentations, conference presentations, reading groups, and doctoral support groups. Finally it served as a therapeutic journal in which I aired my excitement, frustrations, fears and insecurities relating to both PLESME and the research.

The journal was completely unstructured and involved free-flowing writing that was seldom edited or spell checked. This 'free-flowing' style meant gains and losses. On the one hand, it helped to make the journal something I wanted to do and a space in which I could write 'for myself' without immediate concern for a broader audience[13]. On the other hand, the journal entries are useful data sources but the 'roughness' of the entries makes it 'messy' when using the entries as 'quotable' data in the dissertation. In the sense that the journal entries capture some of the excitement and frustration experienced in the research process, they provide a window to the reflexivity of this process. While this reflexivity privileges the voice of the researcher, it is nevertheless important that 'first hand' data relating to this process be included.

In this study I have thus used journal entries as data in their original form. So while I have corrected basic spelling errors I have not edited entries since this could involve possible distortions to the data.

The interviews

The research interview can be understood as a two-person conversation initiated by the interviewer for the purpose of gathering research-related information (Cohen & Manion 1980). While this definition of a research interview makes sense, it limits the possibility that a research interview may have a dual purpose. In the interviews in this study data was clearly gathered for research purposes, but the interviews also served as a means of providing teachers with an opportunity to reflect individually with myself (as both researcher and co-ordinator of PLESME) on various issues. Furthermore, such interviews provided a wide range of information that was useful not only to the research but to PLESME. Perhaps a broader definition of a research interview is necessary especially as relates to research with a strong developmental focus. Riessman's (1993) definition of interviews as conversations in which both participants develop meaning together is possibly more suitable in this respect.

[12] Teacher journals were not used in PLESME. While I believe that teacher journals can be an effective device to aid reflection and support teacher learning (and provide useful data and insights into teacher learning) I was concerned that requesting that teachers keep journals would place too much additional pressure on teachers' time.
[13] Of course what I choose to include from the journal as data for this study is aimed at a broader audience.

As can be seen from the summary table above there were, over the two-year period, three structured[14] interviews which all related broadly to teachers' understanding and practice of the new curriculum, who teachers talked to about their practice, and teachers' understanding of their process of learning as related to PLESME. The interview questions for these interviews are included in Appendix 5.

While it was hoped that interviews would be semi-structured, meaning the interview assumes the appearance of a natural and interesting conversation while being controlled and channelled in service of the research interest (Hitchcock & Hughes, 1989), especially in the case of the first interview, interviews took the form of a structured, question-response interview. The latter interviews took the shape of being more semi-structured in the sense that interviews indeed became interesting conversations stimulated by a set of questions and probes[15]. Yes or no type questions were avoided in all interviews. All interviews were conducted individually.

The third interview (in August 2000) was unstructured, in the sense of being a more open situation with more flexibility and freedom (Cohen & Manion, 1994). It related to my need to explore the issue of race for the purposes of reflecting on this aspect in the research (see Chapter 3). While unstructured, these interviews were not unplanned and probes were used if the opening explanation for the conversation did not yield discussion on teachers' views on relationships in PLESME, i.e. whether they experienced any race tensions and how they saw my role (and my race) in PLESME. In this sense this interview can be understood as a 'conversation with a purpose' (Hitchcock & Hughes, 1989, p.87).

It is important to note how the nature of the interviews changed over time. In the first interviews, conducted prior to PLESME workshops, teachers tended to offer responses, which were restricted to the questions asked. I found it necessary to use probes on questions, especially those relating to the new curriculum outcomes. I felt an uneasiness asking teachers what they thought the outcomes meant especially when they responded with some unease that 'nothing comes to mind.' I felt that since I had been unable to establish relationships of trust as yet (due to limited interactions with

[14] The interview was structured in the sense that the content was organized in advance and the wording of the questions was pre-determined (Cohen & Manion, 1980).
[15] A probe is a question used to gain more information about an issue raised in the primary question. It differs from a prompt that offers possible answers (Nyabanyaba 2001). Prompts were not generally used in the interviews.

teachers), the interview could be considered evaluative and that teachers might think that there were certain 'correct' answers I was expecting.

While I had taken great care to explain, at the start of each interview that the questions did not require any specific answers, and that the interviews were in no way evaluative, without sincerity and trust having been established (through longer term experiences) why should teachers 'trust' my opening explanation? After all, I had approached schools with the district workers and it was still to be established that PLESME was truly 'independent' from the districts.

Therefore, in the first interviews, in order to reduce the stress teachers were experiencing when struggling to find a meaning for the new MLMMS outcomes I would move out of my role as 'interviewer' and explain that the outcomes were couched in very difficult language and that many educators, including myself, were still trying to come to grips with what they meant. In some cases I would explain what I thought some of the outcomes meant (thus shifting into my role as co-ordinator of PLESME).

The second interview was conducted six months later and by this stage relationships of trust had been established. Teachers no longer saw the interviews as threatening or judgemental but rather as an opportunity to engage with me and reflect on what they thought, what they experienced and how their practice had changed[16]. While the interview questions were similar to the first interview, I was less dependent on them as many questions were spontaneously responded to (often before they had been asked).

The main difficulty in these interviews related to the unexpected increased length of time in teachers responses. Teachers enthusiastically responded with a wide range of examples from their own practice, providing many anecdotes of their experiences as a result of participating in PLESME. While providing very rich data the extended time sometimes conflicted with other teacher commitments (interviews were usually conducted during break or after school). This meant that if interviews ran over time teachers were sometimes late for class or late for after school activities.

[16] I use the word change here because it is the word used by teachers in the interviews.

This created an ethical dilemma: on the one hand interviews caused some disruptions to school activities but on the other hand teachers insisted on making alternative arrangements so that they could continue with the interview. After careful consideration I decided that it was the teacher's decision whether to cut the interview short, reschedule it for another time or make alternative arrangements so that the interview could continue. In a few cases this meant that students were left to work on their own for part of a lesson.

Subsequent interviews were similar and I learnt to become comfortable with the silent pauses while teachers were thinking. (The good relations that developed over time made this easier). I also found that my writing detailed notes in interviews, while reducing the feel of a two-way conversation, enabled teachers to not feel rushed in their responses and gave teachers time to think about what else they wanted to say. In this way the tool of paper and pen recording (used primarily as back up for tape recordings) influenced the interview in that it allowed teachers comfortable time in which to think about their responses.

All interviews were tape-recorded and detailed notes were taken as back-up[17] for all interviews except the first set. The first set of interviews were transcribed and then analysed using a range of data analysis techniques. First, I brought selected data to my doctoral seminar group for ideas on how to proceed. Secondly I initially subjected the data to a text based alpha programme in which I categorized all the teacher utterances according to various themes. This programme then allowed me to call up utterances relating to a specific category or theme. While this was relatively useful in forming an analysis of the data and identifying common themes, I did not believe that the time it took was justified. I therefore abandoned this tool in further analysis.

The initial analysis of the first set of interviews informed subsequent interviews and questionnaires and led me to develop a diagrammatic tool for accessing communities in which teachers were engaging about mathematics education and education in general. In this sense the data collection processes were mutually developmental (Adler, 1996) in that 'superficial' analysis of each data source framed aspects of the next cycle of data collection.

[17] After I lost, to a burglary, a number of videotapes of PLESME workshops and of one of the teacher's lessons I decided to not rely too heavily on 'tapes' which could be damaged or stolen.

The questionnaires

The first questionnaire primarily involved basic information gathering. The information related to teachers' qualifications, teaching experience, previous workshops attended and views of mathematics and mathematics teaching (see Appendix 6). Subsequent questionnaires (see Appendix 7) asked similar questions to those in interviews. That is they related broadly to teachers' understanding and practice of the new curriculum, who teachers talked to about their practice and teachers understanding of their process of learning as relates to PLESME.

Questionnaires were used alternately to the interviews and were useful in the sense that they provided another context for teachers to reflect on their practice. Written responses can often differ from verbal responses because the nature of the instrument and the activity of writing. The questionnaires enabled teachers time to organise and revise their thoughts and provide access to 'written discourses' that can be different from 'verbal discourses' because the activity of filling in a questionnaire positions teachers differently to interviews.

In the case of the November 1999 questionnaire, the questionnaire *replaced* a planned interview. This decision was made not on the basis that it was a better instrument but in response to extreme time pressures at schools as a result of time lost due to the strikes (see Chapter 3) and preparations for end of year examinations. The questionnaire enabled teachers to respond to questions in their own time (teachers were given between two to three weeks to return it). The advantage of this questionnaire over the interview was that it involved less travel time and involved less planning in terms of scheduling appointments with teachers.

The classroom observations, videos and video reflection sessions

All participating PLESME teachers were observed in their classes at three different periods throughout PLESME. In each of these observations, teachers selected the time and class to be observed and the content of the lesson. While the observations and videos were part of PLESME *per se*, teachers were given the option of not being observed or video recorded if they felt uncomfortable with it. All teachers welcomed the video except two teachers who requested, in the first set of visits, not to be videod. These two teachers subsequently withdrew from PLESME due to sports commitments. Each observation was videod and this recording was used, primarily, as a tool

for enabling teachers to reflect on their teaching. At the end of PLESME teachers were given a video-copy of all their recorded lessons. Some teachers have used these videos as stimuli for holding discussions with colleagues in their schools about implementing new curriculum ideas.

The observations served both a research purpose (in that they provided insight into the nature of teacher learning in relation to what they did) and a professional development purpose (in that they were used to stimulate reflection and discussion on practice). An observation schedule was used to help guide observations and reflect on aspects relating to the research questions (see Appendix 8). Detailed notes were taken on the content and flow of each lesson and 'critical incidents' were noted. Videos provided back-up for these notes and were transcribed where sections of teachers lessons were used as illustrative of arguments made in this study.

In relation to this research method I adopted the stance of 'observer as participant' (Merriam, 1998, p.101) in that my primary activity was observation, but I participated in the lesson in the sense that my physical presence was felt and acknowledged (and I was occasionally asked to help a learner or share my opinion).

The first observation was conducted at the start of PLESME. That is only one or two workshops had been held by the time each teacher was observed. These workshops dealt with general issues relating to Curriculum 2005 and were not specific to MLMMS. It was explained to teachers at the start that the observations and videos were not evaluative but rather a tool for enabling reflective discussions on practice. However, in the absence of an established relationship of trust, in the first observations it seemed that teachers were not fully at ease with the video and were not convinced that the observation and video would not be used for evaluative purposes – be that informally, for 'accreditation' in PLESME or for passing on information to the districts or Department of Education. Each observation usually spanned a double lesson (approximately 45–70 minutes).

Viewing the video and reflective discussion would take place after each observation (later in the day or the next day if necessary). The video enabled 'stimulated recall' as an aid to teacher reflection. The form these sessions took was for the teacher (or in some cases teachers) and myself to watch the video together in an office or a classroom. We would let the video run and we would pause when we wanted to discuss something. Occasionally I would pause the video and ask the

teacher what they thought a learner meant by a specific comment, or in some cases to clarify a mathematical misconception teachers and/or learners might have had in lessons.

Thereafter we would reflect on the lesson more generally, discuss ideas for future lessons and relate the lesson to the various MLMMS outcomes that teachers were working toward in the lesson. In the first reflective sessions the dominant reflective comment by teachers related to their voice and style of teaching.

The first video served as an important 'icebreaker' for future videos and for establishing 'teacher competence' as the baseline from which PLESME was working. With the permission of the teachers I collated approximately five minutes of each teachers' lesson onto a video-tape as illustrative of various aspects of their teaching, which I saw to be dealing with a range of MLMMS specific outcomes and with learner-centred practice. From teacher lessons I was able to find 'illustrative snippets' relating to each of the MLMMS outcomes except the one relating to data.

This collated video was used deliberately to make the point to teachers that PLESME did not assume that teachers were 'deficient' and that teachers were not expected to abandon all previous practice. The video also served to provide concrete examples of MLMMS outcomes that teachers could refer to in workshop discussions about MLMMS. It furthermore served to demonstrate that the video was indeed a tool for learning rather than an evaluative tool. In the workshop I emphasized that while there was much to learn about the new curriculum there was clearly a strong basis of experience from which we could learn more.

In the second set of observations, which took place six months later, teachers were encouraged to try out new ideas so as to make use of the video as a tool for reflecting on using these ideas in practice. Once again watching the video subsequent to the lesson enabled 'stimulated recall' and reflective discussion. Since conscious and structured reflection is a learnt practice (rather than necessarily an intuitive practice), teachers were provided structured action-reflection templates (see Appendix 4) as tools to help them reflect on their lessons. Again lessons tended to be double periods lasting 45-70 minutes.

By this time it was clear that teachers did not see the observations (or videos) as evaluative or threatening. One teacher, Delia, noted in a discussion with me that at first she was nervous of the

video but by the time of the second video she decided to use it as an opportunity to try something new and to see what happened [Journal, June 1999].

In some cases teachers invited colleagues to watch their video with them and to participate in the reflective discussions. These discussions now tended to focus more on the mathematical content of the lesson and on the teacher's use of learner-centred practices. Discussions also looked at the MLMMS outcomes teachers were drawing on and it was clear that teachers were integrating a much wider range of outcomes into lessons than was evident in the first videos.

The third and final observations and reflective discussions were similar except that the observations took place over two days so that consecutive lessons could be observed. This meant that approximately 80-120 minutes of lesson time was captured per teacher.

The networking diagrams

From analysis of the initial teacher interviews it seemed that the opportunity for, and nature of, teacher 'talk' relating to mathematics teaching varied greatly. Because understanding teacher learning in relation to participation in the PLESME community of practice is a central aspect of this research I believed it necessary to identify possible overlapping or connected communities of practice that PLESME teachers participated in. For this reason I designed a diagrammatic activity in which teachers were asked to represent the wide range of groups or individuals that they talked to about mathematics education or education in general.

The diagram provided useful information from which to plan ways to enhance PLESME networking and broader participation of teachers in mathematics education discussions beyond PLESME. This was important since an aim of PLESME was to support and enable teacher networking with a wide range of education related organizations and people. Teachers used arrows to indicate the frequency and primary direction of conversations and teachers used various labels (e.g. 'administrative issues') to describe the 'nature' of those conversations. An example of teacher's diagrammatic representations is included in Appendix 9.

Other data sources that inform this study

A wide range of information and documents were collected throughout PLESME. For example worksheets, examinations and resources that teachers brought to workshops to share with others, papers teachers presented at AMESA, proposals teachers wrote for funding of mathematics projects and newspaper clippings relating to curriculum 2005 or to schools in the Eldorado Park and Soweto area. In addition some of the earlier PLESME workshops were video recorded for the purposes of assisting others who might wish to run similar curriculum related workshops in the future. These 'miscellaneous' data sources have informed the research in various ways and will be referred to where applicable.

The summary of the range of data sources given above clearly shows that data was collected both on what teachers *said* and *did*, in a range of different activities and contexts. Thus in Lave and Wenger's (1991) terms the data include teachers 'talking about practice' (interviews, questionnaires, video reflections) and 'talking within practice' (field notes of PLESME workshops, classroom observations and videos). The table below provides a diagrammatic representation of the methodological model of this study.

Table 4.2: The methodological model for the study

Teacher activity 'say and do'	**Data Sources/ Activities**
Talking – about teaching practice	Interviews, questionnaires, journal
Talking - within teaching practice	Observation notes/videos, journal
Talking - about PLESME practice	Interviews, questionnaires, journal
Talking - within PLESME practice	Interviews, questionnaires, journal
Actions - in PLESME practice	Journal, videos of workshops
Actions - in teaching practice	Observation notes/videos, journal
Actions - in broader professional practice	Interviews, questionnaires, journals

Part 2: Ethics and the Research Process

There is increasing awareness, in the field of social science and education, of the importance of addressing moral and ethical issues with respect to those involved in research (Cohen & Manion, 1994). There are several writers offering advice on how to proceed ethically without threatening the validity of the research (see Cohen & Manion, 1994; Merriam, 1998). These writings raise some useful ethical issues for researchers to think about before conducting their research. In some cases writers provide helpful checklists and or tips relating to issues of the rights of the researched. For example, informed consent, access and acceptance, privacy, anonymity and confidentiality.

I will briefly reflect on each of these in relation to how they featured in this research study. These reflections should be viewed in the context of other ethical issues, such as race issues and the exclusion of some teachers from participation in the study. These contexts, and their centrality to this study, were examined in detail in Chapter 3. In this part of the chapter I explore several ethical issues raised commonly in literature on qualitative educational research. That is, I examine ethical concerns relating to the rights of the researched, informed consent, access and acceptance, privacy, anonymity and confidentiality. I relate these to the ethical challenges faced in this research drawing particularly on the work of South African researchers (Vithal, 1998; Setati, 2000; Adler & Lerman,[18] in press).

While various issues emerge from the South African context, and are made particularly visible by this context, I do not believe that the issues are limited to South Africa. I believe the ethical issues that are particularly visible in such contexts are illuminatory of issues in less affluent contexts in first world countries around the world and that the insights gained from confronting these issues have much to offer other contexts. The research conducted in various South African contexts is not 'exotic' and should not be 'othered.' Rather these contexts should be seen as opportunities for illuminating research issues that might be taken for granted in other countries. For example, why should the issue of race be particular to research in mathematics education in South Africa? Surely racial issues are not specific to South Africa.

[18] While Lerman is not South African he collaborates in this paper with Adler. The paper is focused on a South African research study and on the experiences of various South African doctoral students (myself included) supervised by Adler and co-supervised by Lerman. Lerman has worked closely, for several years, with the doctoral students in South Africa.

In many ‘first world’ countries white researchers conduct studies in schools or areas dominated by ‘people of colour’, where the languages spoken are different to the dominant language of the country and where there are cultural differences in the background of the researcher and the researched.

The rights of the researched

Cohen & Manion (1994) refer to the ‘costs/benefits ratio’ (p.347) which refers to the *balance* between the demands placed on the researcher in pursuit of truth and the rights of the researched, which may be potentially threatened by the research. In this research study I do not view this dilemma as one requiring a ‘balance’ but rather as a reality that constantly demands reflection and action to ensure that the research does not place unfair demands or pressure on teachers[19] and that the process of reporting the research does not compromise the researched. The rights of the teachers in this study must take precedence.

I argue that this as unavoidable since teachers have a right to withdraw from the research at any stage and therefore any compromise (be it in terms of achieving ‘balance’) could encourage the withdrawal of data by teachers resulting in further implications for the validity of the study. Furthermore, as discussed earlier in this chapter, good relations with teachers have been central to this study and it would be in my view ethically problematic to exploit ‘good relations’ without reciprocating by constantly considering whether the research is compromising teachers in any way.

One issue relating to this study that I feel might place teachers in a difficult position relates to comments made by teachers about the Department of Education and the education districts. If the research is made public it could place a strain on relations between teachers and district workers. However, the teachers in the study have not asked that this information be withdrawn and feel that the confidentiality provided (discussed below) sufficiently protects them.

In respect to the costs/benefits ratio I found it useful as a guide to constantly ask myself whether I would be comfortable with the teachers reading what I was writing (or presenting). Of course this

[19] At one point a University colleague asked if I would give the PLESME teachers a research questionnaire to fill in for his research. I declined since I did not want to ‘exploit teachers’ goodwill’. This raised a dilemma for me, should I have let teachers decide for themselves? On the other hand would teachers have felt compelled to participate?

did not mean that the research is uncritical; only that teachers should feel comfortable that what is written is a fair reflection of our work together and that they are comfortable with the possible uses of the research. Focusing the research on the process of teacher learning rather than on teacher change (according to predefined outcomes) helped avoid commonly used teacher deficit discourse (see Chapter 3) and thus reduced some of the ethical concerns related to the use (or abuse) of research to contribute to a discourse of teacher failure.

Another issue related to the rights of the researcher is the issue of payment of teachers for participation in research. This issue has been debated at length in many research seminars. Some of the questions are: if a researcher has sufficient funds to pay teachers for participation does this not set a precedent for all research involving teachers? If we pay teachers should we also pay learners? What of research projects with limited funding that cannot afford to pay teachers for participation? In the South African context, where resources are limited, can we afford to pay teachers for their participation? Is it not part of the profession of teaching to be involved in research relating to that profession provided it is ethically conducted? It is beyond the scope of this paper to deal with these questions in depth (for this see Setati, 2000), but it is important that I expand briefly on how this issue was dealt with in the context of this research.

Like Setati (2000) I felt it problematic to pay teachers for their participation in the research. I did not want teachers to participate because of a financial incentive and I did not want them to feel bound to the research because of that incentive. I felt the issue of paying teachers would set a precedent and could influence the research in unpredictable ways. Rather, I saw the reciprocity of the research process to be the central motivating factor for why teachers would participate and continue to participate in the research. I elaborate on this briefly.

Cohen & Manion (1994) do not refer to the issue of reciprocity in their discussion of ethical issues relating to education except to say that it is important to discuss the possible benefits of the research for the researched. This issue is however central to this research study and I believe central to much research with teachers in South Africa (see Setati, 2000). The issue is highlighted in South Africa because of a history of research traditions where ethical issues have been marginalized (Vithal, 1998). This history has therefore resulted in increased awareness of possible ‘abuse’ of teachers by researchers (see Mahlomaholo & Matobaka, 1999).

Setati (2000) questions the dichotomy of research *with* as opposed to *on* teachers. This dichotomy, she argues, posits power as being unidirectional which in her experience, and my own, is not the case.

> We cannot wish away the power relations between the researcher and the teacher, however, if research is done in an ethical way there is bound to be mutuality about it (p.512).

Setati (2000) illustrates the way in which, in her research, reciprocity enabled teachers to 'pursue their own agendas while fulfilling the researcher's agenda' (p.519). She argues that the issue then becomes how researchers strengthen reciprocal relationships. Vithal (2000) argues that choice, negotiation and reciprocity are important features of any democratic relationship. Vithal (2000) defines reciprocity as that which 'ensures that the goals and outcomes of the research process will meet the needs and interests of both the researcher and the research participants…reciprocity keeps at bay the possibility for the research process to collapse by helping to secure the commitment and participation of the research participants' (p.572).

Indeed reciprocity was a central feature of this research. The issue of reciprocity in this research is to some extent clouded by my dual role as researcher and co-ordinator of PLESME. That is, participation in PLESME enabled teachers to pursue their own agendas, and provided a small honorarium with which participating teachers could purchase education related resources for their schools. (For example, the honorarium would be sufficient for a school to buy a television set). However being involved in some activities which could be considered primarily research activities clearly had reciprocal elements. This was evidenced by teachers' willingness to participate in interviews and their use of interviews and questionnaires as an opportunity for reflection and for 'being heard'.

Clearly research on teachers is contentious and people are increasingly asking questions about how teachers benefit from research (see Setati, 2000). This issue was raised in relation to this research study at a teachers meeting and was then brought to a PLESME workshop for discussion. Here are the notes from my journal entry relating to this:

> Barry raised that "I don't want to hurt your feeling but in Soweto a teacher said to me that Mellony is using you because she is getting a PhD out of you." I explained that I knew that

there were debates around these issues and that research can sometimes abuse teachers. I took the opportunity to remind teachers that at any stage they could pull any of the data I had noted from them out of the research and that they could do this later if they chose. He said that he had said to the teacher "What? Her using us? We use her *stukkend*[20]." The group reiterated that they felt they got a lot out and said that the research had been explained clearly to them at the beginning and that they were happy with it and that I was open about it with them. I again reiterated their opportunity to withdraw and thanked them for their support and them giving me the opportunity to learn so much from them… After the workshop Barry stayed to chat about his school and again reiterated that this was his only forum for sharing and how much he needed it. He found it hard to work with other teachers at his school… [Journal, 11 May 2000]

This reciprocity is complicated and nuanced, but it is a critical part of ameliorating the power relations that Setati (2000) refers to.

Informed consent, access and acceptance

According to Cohen & Manion (1994) informed consent is the bedrock of ethical procedures. In Chapter 3 I describe how through my role as co-ordinator of PLESME I gained access to the teachers who became PLESME participants. In relation to planning the research, I arranged a meeting with teachers where I explained (and opened for question) the nature of the research, the processes involved, the benefits to myself (as researcher and INSET worker) and the possible benefits and losses for teachers (contribution to research on teacher learning but there were time costs involved). I further explained that teachers could choose not to participate in the research and that at any point teachers could withdraw from the research process.

Teachers were reminded at various points throughout PLESME of the option to not continue to participate in the research and of the option to withdraw their data if they wished. No teacher withdrew and I believe the reasons for this relates to two central factors. These are the

[20] Stukkend is an Afrikaans word meaning broken. In this respect, Barry is saying that they, the teachers, are using me as much as they can.

'interpersonal resources[21]' (Cohen & Manion 1994, p. 349) I drew on and the reciprocity inherent in the nature of the researcher/researched relationship of this study[22].

In this study, teacher consent was not considered to be limited to the start of research, or the process of research, but was, and is, ongoing. That is when publishing articles, or using the research for various presentations it is important that teachers be consulted (wherever possible). Thus ethical issues continue post publication and must continue to be addressed.

Anonymity, privacy and confidentiality

At the start of the research I explained to teachers that I would not use their names in the research so as to provide anonymity for participants. Two issues arose in relation to this. Firstly how could I acknowledge teachers individually, in the study, for their invaluable input into the research without using their names? Failing to acknowledge each teacher felt like using an author's ideas without acknowledgement. However, this is an unavoidable tension relating to anonymity.

The second issue relates to the *possibility* of achieving anonymity in a study of this nature. The PLESME group has become known in certain education circles through fieldtrips and conference participation. While individuals might not be recognizable in the research report the teachers, as a group, could be recognized. I therefore ask the question, is anonymity relative? Are there varying degrees of anonymity? Adler & Lerman (in press) raise a similar concern with anonymity when problematic aspects of mathematics teaching are reported of a group of schools with such specialized features that they are recognizable. In this respect, there is a tension between providing detailed contextual information (necessary in such qualitative studies for both ethical and interpretive reasons) and compromising the anonymity of the group being researched.

[21] Cohen & Manion (1994) write that research in education requires 'interpersonal skills of a high order, supported by humane personal and professional values rooted in a shared culture if investigators are to deal effectively with the ethical challenges of the research adventure' (p.349). They note that experience is a 'fine teacher' in this respect. I do believe that my previous INSET and research experience, as well as my genuine commitment, interest and care for the teachers I was working with was very helpful in this respect.

[22] Reciprocity in the research does not preclude the researcher from expressing gratitude to teachers for their participation. On numerous occasions I expressed my appreciation to teachers for their time and commitment and at the PLESME certification celebration I provided each teacher with a book related to curriculum change in South Africa as a token of my appreciation.

Cohen & Manion (1994), distinguishing between anonymity and confidentiality, argue that since face-to-face interviews, field-notes and classroom observations prevent anonymity (in that identities are revealed to the researcher) the most a researcher can promise in these cases is confidentiality. They define confidentiality as meaning that although the researcher knows who has provided the information, they will not make these connections known publicly. However, this notion of confidentiality is still problematic in that it fails to solve the issue of the recognisability of a specialised group to the public.

A further issue in respect to confidentiality relates to recognisability of individuals *within* the group. Since the teachers in PLESME got to know each other well over the two-year period writings about the teachers, despite name changes, are likely to be recognizable from the style and content of what is said[23]. For ethical reasons and for the purposes of validity it was important that teachers were provided access to what had been written about them. This provided teachers the opportunity to challenge what was written if they did not see it as a valid description of what had occurred. In this respect the possibility of being recognized by PLESME colleagues was unavoidable.

I do not believe that some level of 'recognisability' within a group or outside a group to be necessarily problematic. In some cases teachers have requested that their own names be used. Problems arise when what is being used is of a sensitive nature and may lead to unexpected difficulties within the group or when the research is published and used in a public space. In this respect one asks the question of how public is a doctoral thesis? Cohen & Manion (1994) explain that an individual's right to privacy is usually contrasted with the public's right to know. However, if teachers are given the option of withdrawing from the research at any point then their right to privacy[24], should they choose it, surpasses the public's right to know.

[23] I have experienced this myself when reading research of colleagues and immediately recognizing who the person being researched is from the nature of the comments made and by my knowledge of the researcher and the researched having been involved in a project.

[24] Privacy is not only an issue in the research writing but in the process of collecting data. In this sense I believe that a researcher must be sensitive when a teacher is choosing not to answer a question in detail because they wish to maintain privacy and when prompting and probing is appropriate.

Issues relating to 'disruptions' in the data

Vithal (1998) raises the concern that removing disruptions in data impact on the knowledge that is produced through the research. This was raised in the discussion of sampling (Part 1 above) where I highlighted that when teachers withdrew from PLESME, and thus the research, it created a 'double' opportunity sample. Fortunately, the 'disruptions' in this research did not impact in such a way that necessitated a change in the research plan or an adaptation of the research questions. I have dealt with the issue of disruption by including explanations of the contextual factors that influenced PLESME and the research process (see Chapter 3) so that the reader can take this into account when analysing the research.

Adler & Lerman (in press) raise several dilemmas South African researchers face when conducting research in education. These dilemmas are based on the experiences of several researchers involved in doctoral studies (of which I am one). In their paper, *Getting the description right and making it count: Ethical practice in mathematics research education,* they construct a mythical researcher, wanting to research inquiry-based mathematics in schools. In the field, the researcher finds that there is little available data on this topic since in the sample of teachers he has chosen to work with none of the teachers implement inquiry-based mathematics.

The mythical researcher is forced to confront a difficult dilemma: should he change the question (moving away from the mathematics *per se*) and focus on the context affecting teachers decisions to not implement inquiry-based teaching or should he find a new sample of teachers? Adler & Lerman (in press) explain how failure to examine the context in detail creates descriptions of failure on the part of teachers while focusing on the context takes the focus away from the mathematics that is central for the research to be accepted as *mathematics* education research.

This dilemma was faced head on at the start of my research. From my experiences in impact studies relating to INSET projects I was well aware that ignoring contextual factors played into a discourse of blaming the teachers for the lack of change or failure of an intervention. However I was anxious at the start of the research as to my ability to move the focus of my research away from mathematics education *per se* and to delve deeply into sociological factors. I repeatedly raised my

insecurity (in my journal and in doctoral seminars) exclaiming ‘I am not a sociologist!’ In time I accepted that if I were to conduct research in mathematics education that was both useful and ethical I would have to confront sociological issues in far more depth than I was comfortable with.

Fortunately, the long-term nature of this study allowed me to develop my knowledge of sociological issues and get myself up to speed on a wide range of education literature conducted from a sociological perspective. The result is that the focus of this research study shifts between *mathematics* teacher learning in a broader sociological context (Chapter 6 and 7) and focusing on that context in itself (Chapter 1, 2 and 3). Thus when the one is in the foreground the other is in the background. However, since the two exist together in a complex interrelationship, it is impossible, especially in the current South African context to focus only on mathematics teacher learning without considering in depth the contextual factors relating to the study.

Furthermore it would be incompatible with the theoretical framework of this study to treat such contextual factors as marginal. Adler & Lerman (in press) similarly point out that it is ‘important to understand that development might well be more effective (in the sense of access and democracy) if research and development activity is grounded in (i.e. takes as its starting point) contextual realities’. In this respect they call on the community of mathematics education researchers to interrogate what makes something count as *mathematics* education research. They write:

> The community is very successful in locating and engaging with issues and challenges where the mathematics is prominent. A focus on the mathematics, however, requires that researchers are always aware of what is out of focus, the overlapping social practices that constitute the teaching and learning situations. We are convinced that the community also needs to be more open to seeking questions and answers where the mathematics recedes behind a myriad of intersecting social and political issues.
>
> Let us be clear: social and political issues are not an irritation that gets in the way of research in mathematics education. We consider it our ethical responsibility to seek out those settings for research. Otherwise we collude in denying access to power and control over the lives of the majority of students.

Part 3: The Process of Data Analysis

The most demanding challenge to this study has been managing the enormous amount of data collected over two and a half years. As explained, data sets were available for the fourteen teachers who participated regularly in PLESME. While data from all the teachers have informed the research process, I chose to narrow the sample of teachers from the fourteen participating teachers to ten teachers so that more in depth analysis would be possible. This reduction was based on not having *full* data sets for three of the participating teachers. One had joined PLESME late, another had not participated in the final research phase since he was about to retire, and another teacher was not a mathematics teacher but had chosen to participate in PLESME and the research (except for the mathematics classroom observations since these were not possible). The fourth teacher was removed from the sample because she taught mathematics at the intermediate phase level (grades 4-6) and the project had focused on developments at the senior phase level.

It was clear that I would not be able to transcribe all of the data for the ten teachers. Taking Riessman's (1993) advice I worked from rough transcriptions and notes of interviews and lessons to identify 'striking features' and find places where more careful transcriptions were necessary.

The data collection processes were mutually developmental (Adler, 1996) in that once each process of data collection was completed I used this data to inform the next process. To do this I first read through the data (for example, read through all questionnaires, or all interviews) that had been collected in order to see what problems there were that needed to be addressed in the next stage of data gathering. Secondly, I did a brief analysis of the main themes that were emerging and wrote summary notes on these. From this, new questions emerged which were explored in subsequent processes of data collection.

In depth analysis of all the data began after PLESME came to an end. I began by reading through the entire data corpus including all journal entries, documentary resources, questionnaires, interviews, classroom observations and the 'odds and ends' that I had. I took Merriam's (1998) advice of striving to have a conversation with the data. I made notes of various themes that were recurring and asked questions about why, what, when, how often etc. Thereafter I reorganized the data into ten data sets corresponding to each teacher. This enabled me to write a summary story for each teacher so that I could look for commonalities and differences in the stories. This also enabled

me to analyse the nature of each teacher's learning separately and then relate these stories to the PLESME community of practice as a whole.

Many themes emerged from the dialectical process of induction and deduction with the data, influenced by the lens through which I was looking. The process of organizing these themes still felt overwhelming. I turned to Strauss & Corbin (1990) for advice and followed their suggestion to identify the core category or central phenomenon that was recurring. This was clearly that teachers were *describing* their learning in ways that indicated changing forms of participation, changing practices, changing ways of being and changing identities (not only in PLESME but in the teachers' schools and communities). And teachers were *explaining* or attributing their learning largely to their engagement in the 'PLESME practice' and its related community (i.e. PLESME teachers, myself, PLESME guest speakers and people in the broader profession of mathematics education).

Furthermore all teachers repeatedly *described* and *explained* their learning in terms of increasing confidence. Teachers related this 'confidence' to engagement in PLESME practices, understanding the new curriculum better, alignment to the PLESME community and thus changing ways of being (identity).

Thus all four of Wenger's (1998) learning components (i.e. practice, meaning, community and identity) emerged clearly in descriptions and explanations of teacher learning in relation to PLESME. These components were strongly associated with the emergent concept of 'confidence' which is unexplored in Wenger's work. Thus the quadrangle of interrelated components of *community, meaning, practice* and *identity* (discussed further in Chapter 5) are used as the primary framework for analysing the data corpus. 'Confidence' was clearly foregrounded by teachers in terms of their descriptions and explanations of learning. It is therefore analysed separately but is considered in relation to the components: meaning, identity, practice and community.

Merriam (1998) says that care should be taken that the categories or themes that 'emerge' reflect the purposes of the research and help answer the research question. The core categories above clearly support the purpose of the research, which is to describe and explain the nature of teacher learning. These core categories, of describing learning in terms of changing ways of being and explaining learning in terms of engagement in PLESME practices and with others, relate (respectively) to the original critical questions of the research. That is: How do teachers interpret

and enact the following new aspects of mathematics education over time? To what extent and how do teachers participate in and make use of a community of practice, stimulated by INSET, in the context of curriculum change?

Strauss & Corbin suggest stating categories as processes. So for example rather than the category 'new curriculum discourse' (relating to the core category of changing ways of being) I categorized data as 'non engagement with new curriculum discourse', 'using the jargon of the new curriculum', 'concretising (with examples) the new curriculum discourse.' This enabled me to identify clear trends in the data over the two and a half year period.

Naming the categories came from three sources, myself as researcher, the teachers as participants and the literature (Merriam, 1998). For example the category: 'concretising the discourse' was coined by myself to describe teachers' use of examples from their own practice to explain how they interpreted an aspect of the new curriculum. The category 'increasing confidence' was derived from the words teachers used to describe their learning. And the categories of 'drawing on the PLESME community of practice' and 'identification and alignment with the broader profession' (relating to the second core phenomenon) drew on the discourse of Lave and Wenger (1991) and Wenger (1998).

Of course, the complexity of this process involved more than finding names to describe the emergent themes. Several processes of categorization involving stating categories, changing categories and refining categories occurred and, in some cases, led to another interview with teachers to collect more information on a theme. For example, the theme of confidence was so prolific in the data that it begged for further interviews with teachers expanding on what they meant by this. Once a category or theme was established, I looked through the data to find additional evidence for the theme or category and to search for 'disconfirming evidence' (Miles & Huberman, 1984). That is cases where the theme or category was absent or cases where the theme was contradicted.

In addition, each category was analysed in terms of its 'properties' such as frequency, extent, intensity, and duration (Strauss & Corbin, 1990). A useful technique for analysing these properties involved counting. Miles & Huberman (1984) note that numbers often get ignored in qualitative research. To identify a theme one isolates an event or phenomenon that has recurred a number of

times. It is useful to make that process of counting the number of times explicit. In this study counting is used, where appropriate, to establish the overall distribution of a category (or occurrence) across the teachers and in some cases the frequency of an occurrence for individual teachers.

I have explained how in response to emergent themes in the data I came to identify the work of Wenger (1998) as particularly useful for this research study. Having read this work clearly influenced the lens through which I analysed the data and indeed provided the theoretical framework for the analysis. Furthermore I have stated that an additional question that emerged from early data analysis is the extent to which social practice theory, in particular the work of Wenger (1998), is helpful in explaining the nature of teacher learning in relation to INSET. This 'theory testing' is not, however, the primary focus of this research study. Instead, in its use of social practice theory as a lens and tool for describing and explaining learning, the study provides insights into the strengths and limitations, and suggestions for extension, of such a theoretical framework for teacher learning. I draw primarily on the work of Wenger (1998) since it draws on earlier work of Lave & Wenger (1991) discussed in more detail in Chapter 5.

While I drew on the work of Strauss & Corbin (1990) and proceeded to do the data analysis in a grounded way, I was clearly influenced by the theoretical framework I was drawing on. Strauss & Corbin (1990) define grounded theory as 'inductively derived from the study of the phenomenon it represents… One does not begin with a theory, then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge' (p.23). In the sense that Lave & Wenger's work influenced the design of PLESME and the research (in so far as the research aimed to examine teacher learning in an INSET project structure to *enhance participation in a community of practice*), the study cannot be considered 'grounded research.'

However, some researchers question the possibility that any research can be truly grounded as researchers are always working within some theoretical framework or frameworks (whether this is stated at the start of the research or not). All researchers come to do research with a lens that is influenced by their experiences and the theories to which they have had access. I see it as a strength of this research that I have endeavoured to make transparent the theoretical and other experiences that influence the lens through which I approached the data. In the words of Adler (1996) 'the analysis is neither one of unspoilt or unframed grounded theory. Nor is it an attempt to fit data into

pre-existing categories. It is rather a dialectical process that involves both induction and deduction, theoretically informed theory generation' (p.108).

Adler (1996), drawing on Erickson (1986), notes that after an initial reading of all of the data, the researcher should make an assertion and choose an excerpt from the data and write a narrative vignette that supports that assertion. This 'analytic narrative vignette' (Erickson, 1986, p.149) provides the foundation for effective reporting of fieldwork and provides a means to identify and substantiate assertions, concepts and ideas that emerge through the study. The use of the analytic narrative vignettes and quotes provided an effective way of dealing with the masses of data that had been generated and provided an effective means for providing particular descriptions relating to what teachers said and did. It also provided a means for elaborating on the themes that emerged from the study in such a way that provided richness and depth. According to Erickson (1986):

> Analytic narrative is the foundation of an effective report of fieldwork research. The narrative vignette is a vivid portrayal of the conduct of an event of everyday life, in which the sights and sounds of what was being said and done are described in the natural sequence of their occurrence in real time… The narrative vignette has functions that are rhetorical, analytic and evidentiary. The vignette persuades the reader that things were in the setting as the author claims… Such narrative is analytic – certain features of social action and meaning are highlighted, others are presented less prominently or not mentioned at all…. The task of the narrator is twofold. The first task is didactic…the second task of the narrator is rhetorical, by providing adequate evidence that the author has made a valid analysis of what the happening meant from the point of view of the actors in the event…. It is the task of more general synoptic description to persuade the reader that the event described was typical, that is, that one can generalize from this instance to other analogous instances in the author's data corpus (pp. 149-150).

Direct quotes from those observed are used to supplement vignettes and to provide the reader access to the views of the teachers. A difficulty of working with analytic narrative vignettes and direct quotes is justifying their selection from the data. Clearly it is not enough that the researcher simply finds the incident interesting. The significance of the incident must be established by citing similar instances, and by reporting the overall distribution of instances (Adler, 1996; Erickson, 1986). Analysing specific incidents with specific teachers in depth, where appropriate, provides the

reader with richer insights into the nature of teacher learning. However the richness of the description is not what makes the vignette or quote valid, but rather the combination of the richness and the interpretive perspective that enables validity (Erickson, 1986).

The vignettes used in this study are however not generalizations, nor are they typical or rare, but rather they are instances that usefully illustrate the themes that emerged in exploring the nature of teacher's learning in relation to an INSET practice. That is throughout this study the particular incidents will be located in relation to the general. Similarly when examining, for example, aspects of the PLESME community of practice, the general is related to individual instances that make up the 'general.' This relates to the unit of analysis for the research study. In resonance with the theoretical framework, experiences of individual teachers are seen in relation to the PLESME community of practice and the PLESME community of practice is viewed in relation to the individual teachers who constitute it. Thus the unit of analysis for the study is *both* the teacher and the PLESME community of practice viewed in dynamic relation to each other. That is the unit of analysis is both the *teacher in PLESME* and *PLESME in the teacher.*

Part 4: Trustworthiness: Reliability and Validity

Reliability and validity are central in any discussion of rigor in scientific research (Silverman, 1993) and validity is the key issue in debates over the legitimacy of qualitative research (Maxwell, 1992). However the issues related to these concepts differ depending on the nature of the research conducted and the philosophical and ontological assumptions of the researcher. In some research traditions achieving 'objectivity' is crucial in judging the reliability or validity of a study. This assumes, firstly, that objectivity is possible and, secondly, that there is an empirical reality out there that can be objectively represented.

These assumptions conflict with the assumptions of this research study. Above I explained that at the basis of my choice of qualitative methods are the assumptions that reality is constructed by individuals, interacting in their social worlds, and that meaning is embedded in individuals experiences and is mediated by the researcher's perceptions. Some researchers have argued that objectivity is a myth and that all research is infused with values, positions, choices and power relations (Adler, 1996). From this perspective notions of rigor, reliability and validity need to be reconceptualised if they are to be useful for this qualitative study. It is to this that I now turn.

Reliability generally refers to the extent to which research findings can be replicated. However, as Merriam (1998) notes, 'reliability is problematic in the social sciences simply because human behaviour is never static' (p.205). This notion of reliability is rooted in quantitative and positivist research traditions. In some studies reliability has been interpreted to refer to the degree of consistency with which different observers assign the same category to data (Hammersley, 1992 in Silverman, 1993, p.145). However, Adler (1996) citing Marton (1988) argues that since categories are a discovery it is unreasonable to expect others to discover the same categories as the researcher. Rather, she argues, reliability should establish to what extent these already discovered categories are recognisable to others.

In this respect the researcher can use 'inter-rater reliability' (Silverman, 1993) by getting others to look at the same data according to those categories and to see whether the categories are recognizable in the data. In this study, as far as possible, data was made available to colleagues and supervisors so as to provide a means of checking the categories and themes that I was drawing from the data. Furthermore as far as possible I have provided vignettes of data in the teachers 'own words' so as to enable the reader to make his or her own judgements as to the recognisability of the categories and themes I have drawn from the data.

Validity too must take on different meanings and must use different techniques in relation to qualitative research. Adler (1996) notes that when using qualitative techniques validity lies in the relationship between interpretation and evidence. Qualitative research depends on two types of validity, that is, descriptive and interpretive validity, and, theoretical and explanatory validity (Maxwell, 1992). The first is achieved through careful transcriptions and recognizable categories that remain close to the data. The second is achieved by systematically linking theoretical concepts to the theoretical framework of the study.

Validity also concerns transparency (Nyabanyaba, 2002). In this sense it is important that researchers supply as far as possible the data from which various assertions are made. More importantly however I believe the researcher must make available, as far as possible, information relating to the context of the research and the nature of the relationship between the researcher and the researched. Merriam (1999) supports this point and argues that in interpretive inquiry quality of research must be based on considering the relational aspects of the research process (for example,

the knower and the known). He argues that in doing so the distinction between quality and ethics falls away.

Riessman (1993) argues that in order to make it possible for others to determine the trustworthiness of a study the author must: describe how interpretations were produced; make visible what she did; specify how she accomplished successive transformations, and make primary data available to other researchers. In addition, Erickson (1986) notes that, as relates to the concern for rigor, a report must be intelligible in the relations drawn, display a range of evidence that warrants assertions the author makes, and make explicit the author's own interpretive stance (theoretically and personally). He argues that presenting all this enables the reader to become a "co-analyst".

Within the research process I have worked towards keeping description and analysis 'close to the data'. I have used 'respondent validation' and 'inter-rater reliability'. I have provided extensive discussion of contextual and relational factors impacting on the study (and provided explanation of the dynamic nature of these over the research period). I have described the reflexivity of research processes and I have engaged with ethical issues in depth. In so doing I have strived to achieve trustworthiness, rigor, descriptive and interpretive, and, theoretical and explanatory validity as required in qualitative research.

Part 5: Generalisability, Generativity and Exemplarity

> Teacher education is a social enterprise and has the dynamic qualities of social events. Each incident of social interaction is *embedded* in a social context that is broader than the boundaries of an observer's vision, reaching back into the history that led up to it and reaching out to a constellation or network of related impinging social events and social forces…Generalization is possible only with great caution. "Exporting" generalizations across cultures is even more difficult than applying insights within a culture but in a different social context. The mediating intelligence and understanding of the user may make such cautious application possible (Tabachnick, 1989, p.155).

Many qualitative researchers struggle with the notion of generalisability. Some argue that generalisability is not *central* to qualitative research because it is inappropriate (Adler, 1996; Nyabanyaba, 2002). In this study I have described in detail the sample of the study and have

explained the ways in which the teachers were ‘atypical’ of many teachers of mathematics in South Africa. Indeed, the enormous diversity of educational contexts makes it very difficult for any population of teachers to be considered ‘typical’ of teachers throughout the country.

For this reason, some South African educators argue that rather than looking for generalisability in research one should focus instead on its generativity (Adler, 1996; Nyabanyaba, 2002). That is, to what extent does the language of description and the themes, which emerge from the study, generate further research questions and provide explanatory models for a research topic. In this respect, the generativity of this study needs to be considered in relation to the extent to which the ideas, themes, issues raised and language of description is used to inform and stimulate debate in exploring alternative models of teacher education in South Africa, as well as to research relating to mathematics teacher education and applying social pratice theory to teacher education. I believe this study is generative in all of the above respects.

While I feel it is more appropriate for this research study to be generative, I do not wish to dismiss the issue of generalisability. Instead it is more useful to reconceptualise generalisability in the context of qualitative interpretive research. Tabachnick (1989) argues that for naturalistic research where generalization is left to the reader rather than built into the analysis of the results of the study. Thus the reader is required to make the connections across space and time to a different situation to the one in which the insights were gained. He argues that while the need and role of generalization is important it should not be the main priority. He cites Cronbach (1975):

> Instead of making generalization the ruling consideration in our research, I suggest that we reverse our priorities. An observer …in trying to describe and account for what happened, will give attention to whatever variables were controlled, but he will give equally careful attention to uncontrolled conditions…When we give proper weight to local conditions, any generalization is a working hypothesis, not a conclusion (pp.124-125)

Vithal (2001), in dealing with the difficulty of generalisability in qualitative research, supplements it with the notion of ‘exemplarity.’ She sees the exemplarity function of crucial descriptions as a bridge between generativity and generalisability. She notes that exemplarity can move one into the theoretical totality that inspired the research and through crucial case descriptions, can allow

readers to come to understand and reflect on that context and to know and critique the theory that is generated.

Similarly, I would argue that the use of analytic narrative vignettes and thick descriptions in this study have an exemplarity function that enables the reader to come to understand and reflect on mathematics teacher learning in PLESME in the South African context, and to interrogate the theory that is generated from this study. In addition these narrative vignettes enable the reader to consider the extent to which the findings, themes or phenomenon are applicable (generalisable), or have implications, in other contexts. All research findings are embedded in specific contexts and therefore are not directly transportable to other contexts. However, research findings can exemplify issues that should be explored in a range of contexts and can contribute towards the generation of a cohesive theory on teacher learning.

As noted in the rationale, the field of research on teacher education is in great need of research about teacher learning in multiple opportunities and in a range of contexts (Wilson & Berne, 1999). The contributions of this research emerged from a specific post-apartheid South African educational context at a time of rapid social, political, economic and educational change. The specificity of the South African context should not be seen as a reason for it to be marginalised by the international community. Instead, I argue that the methodological contributions and the findings have relevance to the challenges faced by many researchers in contexts other than South Africa or the 'developing world.' Indeed they also have relevance to other contexts within South Africa. Generalization, as a working hypothesis, is possible and useful provided proper attention is given to local conditions (in both the context that generated the hypothesis and in the new context in which the hypothesis is being considered).

In the sense that this study contributes insights and implications for principles of teacher development, analysis of curriculum change, methodological approaches to researching teacher learning within an INSET practice and for applying a social practice theory framework to analysis of INSET, the study can be considered 'generalisable'. However, a final concern must be noted. As Tabachnick (1989) warns, generalizations are always temporary:

> Whatever our interpretations and explanations, we know that these will illuminate the social behavior we are studying within contexts similar to the ones we examine, but for a short time

only. We must continually replenish our observational data and form new interpretations because “generalizations decay” (p.162).

In summary:

As is evident from Parts 1–3 of this chapter, I have drawn on a wide range of qualitative research methods that have their roots in different forms of qualitative research namely, case study research, grounded research and ethnography. Drawing on various aspects of these research traditions enabled richness and depth in the data. No one of the above research methodologies appropriately describes the nature of this research study. Broadly speaking the methodological approach of this research is best described as an interpretive qualitative approach in which I (as researcher) take the stance of both observer as participant *and* participant as observer (related to my dual roles of researcher and coordinator of PLESME).

In Chapter 3, I explained how my dual role as coordinator of PLESME and researcher in PLESME enabled a powerful dualism and reflexivity in the research. This chapter, in conjunction with Chapter 3, provides the ‘teacher educator/researcher’ with an approach to working with that duality. The study further makes a methodological contribution in its dealing with concerns for ethics in the context of current INSET and research practices in South Africa and elsewhere.

Finally, this chapter offers a methodological approach to researching teacher learning (from the inside of an INSET practice) and contributes methodologically to the broader field of research in mathematics teacher education.

Chapter 5: The theoretical framework for the data analysis

As PLESME and the research process progressed, and I reflected on the data gathered, it was clear that teacher learning was taking place. The challenge was how best to describe the nature of teacher learning and to explain *how* it was occurring. The focus of this chapter is describing the theoretical framework that I use to describe and explain teacher learning in Chapter 6 and Chapter 7 of this study.

The literature that I review in this chapter is focused on that body of literature that most strongly influenced the analysis of teacher learning during PLESME. This analysis has been particularly informed by the work of Lave & Wenger (1991) and of Wenger (1998). Most of this chapter is therefore concerned with exploring and analysing this work.

Of course the process of identifying the work of Lave & Wenger (1991) and Wenger (1998) as particularly useful for the purposes of this study involved becoming submerged in a wide range of literature in the broader field of socio-cultural and situated perspectives on learning; literature that has, of course, influenced the work of this study. It is, however, unnecessary for the purposes of this study to provide a detailed literature review on all the literature that has influenced the formation of my perspective. Instead I focus on the work of Lave & Wenger (1991) and Wenger (1998) and provide some reference to the broader theoretical framework from which their work emerged.

This chapter is therefore structured as follows:

Part 1: The influence of the work of Lave & Wenger on this study.
Part 2: Situating Wenger's work in the broader field from which it emerged.
Part 3: Elaborating Wenger's framework of learning.
Part 4: Some challenges in applying Wenger's framework to a study of teacher learning.

I have drawn on a wide range of literature in this study relating to the following three areas:

- The context of educational and curriculum change in South Africa.
- Teacher Education and INSET (particularly in Mathematics).
- Ethical and methodological issues in research.

I elaborate each of these briefly.

In Chapter 1 and Chapter 2, I drew on South African literature relating to recent historical developments in South Africa's Education system, the current curriculum change process and the introduction and implementation of Curriculum 2005 (including a range of policy documents) in order to support my description and analysis of the broader context within which this study takes place. I supplemented my analysis of the current curriculum change process and the changes in the mathematics curriculum with the work of Bernstein (1982, 1990, 1996, 1999) since he provides useful tools for analysing curriculum change and for identifying possible implications for teachers.

In order to supplement my description and analysis of PLESME (the empirical field for this study) in Chapter 3, I drew on a wide range of literature (both local and international) relating to teacher education and INSET models and theorised about dilemmas in the design of INSET. Similarly, in Chapter 4 I drew on both local and international literature relating to ethical and methodological issues in research in education and in particular research with teachers.

In sum, a wide range of literature is integrated into the work of this thesis.

Part 1: The influence of Lave & Wenger (1991)

How I discovered Lave & Wenger

For many years I have been drawn to the work of those working from a situated cognition perspective (for example, Carraher *et al.*, 1985; Chaiklan & Lave, 1993; Lave, 1988; Saxe, 1990; Schon, 1983; Walkerdine, 1988) and socio-cultural perspectives (for example, Adler 1996; Lerman 1998a; Stein and Brown 1997; Vygotsky 1978; Watson 1998). This interest developed out of my disappointment with cognitivist perspectives. Like many others (for example, Stein & Brown, 1997; Kirshner & Whitson, 1997; Lerman, 2001), I found that psychological cognitivist paradigms were limited in exploring learning as part of a subjective and socially constructed world.

A situated cognition perspective was particularly appealing since it seemed to provide a bridge between cognitivist perspectives and sociological perspectives. Lave & Wenger (1991) explain:

> The notion of situated learning now appears to be a transitory concept, a bridge, between a view according to which cognitive processes (and thus learning) are primary and a view according to which social practice is the primary, generative phenomenon, and learning is one of its characteristics (p.34).

In exploring literature related to research in education from a situated cognition perspective I found that much of this literature drew on the work of Jean Lave and the work she conducted with Ettienne Wenger in 1991. For example, in the book *Situated Cognition: Social, Semiotic, and Psychological Perspectives*, edited by Kirshner & Whitson in 1997, each of the thirteen papers (except one) refer to the work of Lave (1988, 1991, 1993, 1996) and/or Lave & Wenger (1991).

The work of Lave (1988; 1991; 1993; 1996) and Lave & Wenger (1991) are increasingly being drawn on to describe and explain student and teacher learning in the field of *mathematics* (see Adler, 1996; Adler, 1998a; Adler, 2001; Boaler, 1997; Boaler, 1999; Boaler & Greeno, 2001; dos Santos & Matos, 1998; Lerman, 1998; Winbourne & Watson, 1998; Stein & Brown, 1997; Watson, 1998). Lave's popularity with Mathematics Educators resulted in the publication of a book consisting of a collection of papers reflecting current thinking and research in mathematics education that had been influenced by Lave's work. The book *Situated Cognition and the Learning of Mathematics* was edited by Watson in 1998. Watson (1998a) however reminds us that the book does not present a full critique of the application of her work to mathematics.

All eleven papers in this collection, except one (that only drew on Lave's work and not her work with Wenger), draw on the work of Lave & Wenger (1991). It was this widespread use by fellow mathematics educators and colleagues that drew my attention to the work of Lave and more particularly the work of Lave & Wenger (1991) as possibly providing me with a conceptual framework, and a set of general guiding principles, for understanding, analysing, explaining and enabling learning in a way that gave primacy to the local, subjective and socially constructed context within which I was working.

Furthermore, mathematics educators are increasingly noting the importance of Lave and Lave & Wenger's (1991) work for analysing mathematics *teacher* education. For example, Adler (1998) notes that while Lave's model does not easily apply to student learning in mathematics classrooms, it does apply to teacher learning and therefore has application to understanding teacher

development. More recently, Lerman (2001) noted that describing learning in terms of becoming is particularly fruitful for researchers in mathematics teacher education.

However, many acknowledge that Lave & Wenger's (1991) perspective has not yet been developed into a full-blown theory of learning and that there are many difficulties that arise when applying such perspectives to learning mathematics or learning to teach mathematics (Adler, 1998; Watson, 1998). Furthermore, there are few studies that focus on *how* learning is enabled from such a perspective. What are the mechanisms that enable learning to take place from a perspective of 'learning as becoming'? Thus while researchers are creating contexts that enable teacher learning and describe what teachers learn, little has been done to explain *how* those contexts enable learning (Wilson & Berne, 1999).

In this respect I saw the application of Lave & Wenger's perspective of 'learning as becoming' to the context of teacher learning in South Africa as an important contribution to the broader field of literature in need of research in a range of contexts.

Why the work of Lave & Wenger resonates with this study

In Chapter 3, I explained that the work of Lave & Wenger (1991) and the work of Wenger (1998) became particularly appealing for this study due to its resonance with both my personal experiences of learning and my experiences in PLESME. I explained that the design of PLESME was based on the 'common sense' assumption that learning would be enabled and supported by creating a learning environment where collegiality, co-operation, support and a strong sense of community was encouraged. In this sense Lave & Wenger's (1991) notion of 'communities of practice' influenced the design of the research and the design of PLESME.

Another assumption that developed over time in PLESME was that the implementation of the new curriculum would not simply involve replacing 'old' practice with 'new' practice. Rather, implementing the new curriculum would involve a process of fashioning the curriculum in such a way that it became part of the teacher's 'way of being'. This would be enabled through providing teachers access to a range of resources including opportunities to participate in a community engaged with new information, mathematics content, methodological ideas, 'new' discourses, materials, curriculum documents, mathematics educators etc.

In Chapter 4, I explained how the work of Lave & Wenger (1991) and the work of Wenger (1998) cohere with the methodological approach taken in this study. It coheres with the underlying assumptions of that methodological approach (i.e. that reality is constructed by individuals interacting in their social world and that knowledge is both personal and social) and with the methods of data collection (i.e. data included what teachers said and what they did and teachers talking within and about their practices). Their perspective enabled me to take cognisance of the complexity of the many social, political, cultural and economic factors impacting on the study. Lerman (2001) writes:

> The classroom and seminar room are complex sites of political and social influences, socio-cultural interactions and multiple positionings involving class, gender, ethnicity, teacher-student relations and other discursive practices in which power and knowledge are situated. I believe that individualistic accounts cannot do justice to these forces… Describing learning in terms of becoming… is where Lave's approach is particularly fruitful for us as teachers of mathematics and as researchers in mathematics teacher education. Lave's focus on the shaping of identity in social practice emphasizes the centrality of the social relationships constituted and negotiated during classroom learning (pp.17-18).

Their perspective on learning has some political motive in the sense that it moves away from theories that reduce learning to individual mental capacity since these often 'blame marginalized people for being marginal' (Lave, 1996, p.149). They emphasise the importance of 'shifting the analytic focus from the individual as learner to learning as participation in the social world' (Lave & Wenger, 1991).

The danger of 'blaming individuals' resonated with my experience that research, in the context of INSET projects, often tended to blame individual teachers for the lack of take-up of new ideas. As discussed in Chapter 3, it was my sincere intention not to undermine teachers but to move the research from a focus on teacher change towards teacher learning in context. The work of Lave & Wenger similarly focused on the process of learning rather than on teacher change. The resonance of Lave & Wenger's work to this intention is captured in my journal relating to discussions in a reading group in which we were dealing with the work of Lave & Wenger (1991):

> I said I really liked the shift in research from a focus on teaching to a focus on learning, even though we all agreed that we struggled to get this completely. I said I liked it because I

> realised that my previous research tended to focus on a teaching curriculum of my projects. I assessed the success of the project in relation to this teaching curriculum rather than on what teachers had learnt. But what I am trying to do in this research is to move to look at teachers' learning – not as an impact study- but as learning for learning's sake [Journal, July 1999].

The later work of Wenger (1998) was only accessed by me in 2000 and therefore came to influence this research only in the final stages of the data analysis. It is therefore important that I provide some background to those aspects of the earlier work of Lave & Wenger (1991) that particularly resonated with PLESME and the research process. This background is also important as the work of Wenger (1998) that provides the frame for the data analysis in Chapter 7 is steeped in his earlier work with Lave in 1991.

In the next section I do not provide a comprehensive description of the work of Lave & Wenger (1991) but rather focus on those aspects that particularly informed and influenced the research due to their resonance with my experiences prior to and during the research.

Describing the work of Lave & Wenger (1991) in *Situated Learning: Legitimate peripheral participation*

Lave & Wenger's initial intention was to rescue the idea of apprenticeship. Their work is derived from empirical research on learning as apprenticeship in various contexts such as tailoring. According to Lerman (2001) these works developed out of research on socio-constructivist perspectives of learning and have derived their stimulus from Vygotsky (1978, 1986).

Lave & Wenger (1991) (and others, for example, Watson, 1998) locate their work in the broader context of situated learning or situated cognition. According to Lave & Wenger, learning is located in the process of co-participation and not in the heads of individuals; not located in the acquisition of structure but in the increased access of learners to participation, and it is an interactive process in which learners perform various roles. They prioritise the importance of *participation in the practices of a community* and *identity* as primary features of learning:

> As an aspect of social practice, learning involves the whole person; it implies not only a relation to specific activities, but a relation to social communities - it implies becoming a full participant, a member, a kind of person… Learning thus implies becoming a different person

> with respect to the possibilities enabled by these systems of relations…. learning is not merely a condition for membership, but is itself an evolving form of membership (p.53).

> In fact, we have argued that, from the perspective we have developed here, learning and a sense of identity are inseparable: They are aspects of the same phenomenon (p.115).

Since participation in the practices of a community is essential for the development of identity (and therefore of learning) they refine the notion of community for the purposes of learning and define a 'community of practice' as follows:

> A community of practice is a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice. A community of practice is an intrinsic condition for the existence of knowledge, not least because it provides the interpretive support necessary for making sense of its heritage. Thus, participation in the cultural practice in which any knowledge exists is an epistemological principle of learning (p.98).

The notion of access is central in relation to a community of practice:

> To become a full member of a community of practice requires access to a wide range of ongoing activity, old-timers, and other members of the community; and to information, resources, and opportunities for participation. The issue is so central to membership in communities of practice that, in a sense, all that we have said so far is about access (p.101).

Thus for Lave & Wenger learning is not located in the acquisition of structure but in increased access of learners to participating roles in expert performances.

> Such a view offers a means with which to replace an unproblematic notion of cultural transmission/internalisation with a historically situated analysis of relations among activity, the social world, and persons in practice (p.81).

In this respect their perspective on learning has implications for ways for enabling learning. That is, learning is maximized if one maximizes learners' access to participation in, and the resources of, a community of practice in which the development of identities in relation to that community are

supported. They argue that particular tools and techniques for learning are replaced with 'ways of becoming a participant' 'ways of participating' and 'ways in which participants and practices change'.

In this sense, their primary learning mechanism is what they refer to as ‘legitimate peripheral participation’. This is:

> Learning viewed as situated activity has as its central defining characteristic a process that we call *legitimate peripheral participation*. By this we mean to draw attention to the point that learners inevitably participate in communities of practitioners and that the mastery of knowledge and skill requires newcomers to move toward full participation in the sociocultural practices of the community (p.29).

The primary contribution of their work was to characterise learning as legitimate peripheral participation in communities of practice. This characterization challenged traditional forms of teaching:

> Rather than a teacher/learner dyad, this points to a richly diverse field of essential actors and, with it, other forms of relationships of participation (p.56).

In breaking down the teacher/learner dyad they shift from a focus on teaching to a focus on learning and emphasise that teaching is not a precondition for learning. Indeed their work does not deal with the notion of teaching at all. Rather than providing a set of guiding principles for teaching, they provide recommendations for maximising learning (for example, they recommend enabling access to resources).

Through their lack of dealing with the notion of *teaching* Lave & Wenger imply that in addition to teaching not being necessary for learning, teaching is not particularly useful for learning. In this sense Lave & Wenger have reconstituted learning but they have not fully reconstituted teaching. Their disregard for teaching in relation to learning is problematic since even the most traditional forms of teaching (in apprenticeship, everyday and school contexts) have had some success in relation to learning.

Furthermore, their disregard for teaching is especially problematic when applying their work in the context of learning in schools and to the work of teachers. However, many implications for teaching can be derived from their recommended ways of maximising learning. Lave (1996) tries to address the implications of their work for teaching:

> Teaching, by this analysis, is a cross-context, facilitative effort to make high quality educational resources truly available for communities of learners. Great teaching in schools is a process of facilitating the circulation of school knowledgeable skill into the changing identities of students. Teachers are probably recognized as "great" when they are intensely involved in communities of practice in which their identities are changing with respect to (other) learners through their independent activities (p.158).

> School teaching is a special kind of learning practice that must become part of the identity-changing communities of children's practices if it is to have a relationship with their learning (Lave, 1996, p.161).

While Lave (1996) addressed the need for the reconceptualization of teaching in relation to their perspective on learning, this is not picked up by Wenger (1998) and he continues to undermine the value of teaching to the point that he asks: 'How can we minimize teaching so as to maximise learning?' (p.267).

I argue that since the corollary of 'teaching is not a precondition for learning' is not 'teaching does not result in learning' it is important to ask the following: Where is teaching in learning? What conceptualisation of teaching is needed to help maximise learning? What will such a reconceptualisation of teaching mean for the development of identities of teachers? In relation to these questions I argue that much work has to be done on reconceptualising teaching from this perspective on learning. This is discussed in more detail in the following section.

Part 2: Situating Wenger's work in the broader field from which it emerged

As we have seen above, the work of Lave & Wenger moved away from psychological and cognitive explanations of learning to a more social and situated view of learning and a shift from a

focus on the individual as learner to learning as participation in the social world. So too is the work of Wenger (1998) situated within this broader field.

Wenger (1998) notes that his work is a social theory of learning that does not aim to replace other theories of learning but does have its own set of assumptions and its own focus. His work can be considered a theory in that it constitutes a coherent level of analysis and yields a conceptual framework from which to derive general principles for understanding and enabling learning (p.4).

In the Introduction to his book, Wenger goes to great lengths to explain the 'intellectual context' (p.11) of his social theory of learning by placing it at the intersection of various 'axes' of intellectual traditions. These are summarised in the following diagram:

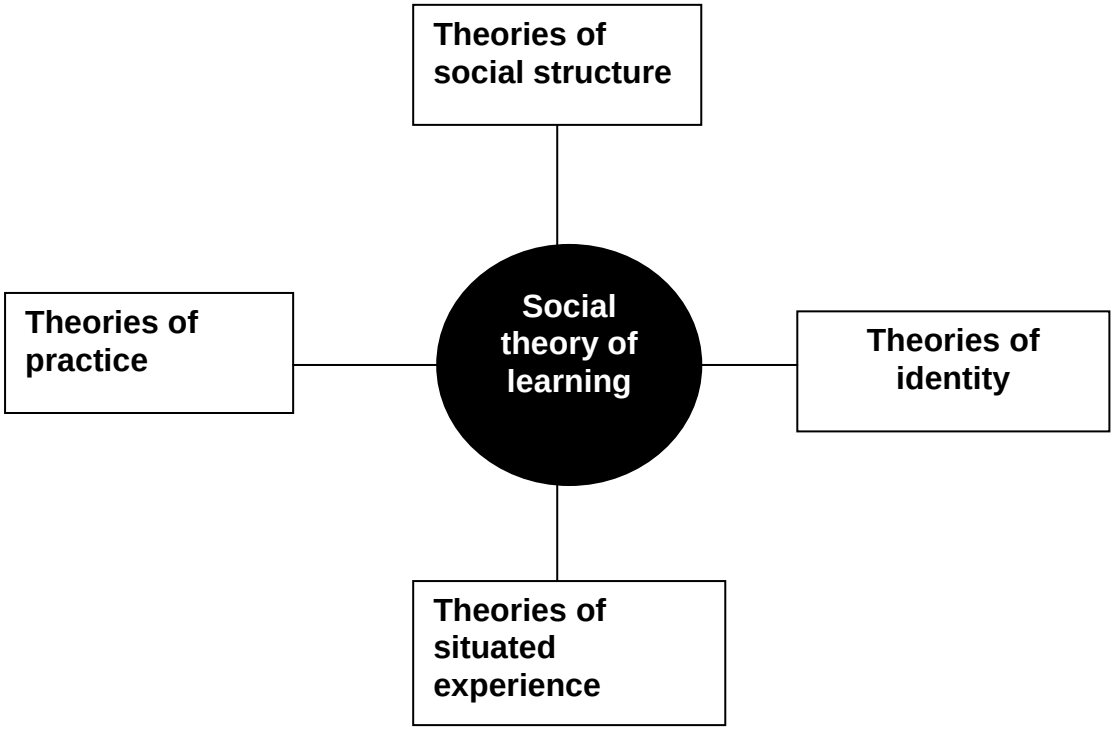


Figure 5.1 Two main axes of relevant traditions

He explains that in the tradition of social theory, the vertical axis is usually central and that a large body of work deals with the tensions between *theories of social structure* and *theories of situated experience*. The former emphasise institutions, norms, cultural systems, discourses and history

while the latter emphasise agency and intentions. In this sense ‘learning as participation’ is caught in the middle. He explains:

> It (learning) takes place through our engagement in actions and interactions, but it embeds this engagement in culture and history. Through these local actions and interactions, learning reproduces and transforms the social structure in which it takes place (p.13). (brackets mine)

However Wenger points out that the horizontal axis is the axis with which his work is mostly concerned but adds that this is ‘set against the backdrop of the vertical one’ (p.13).

On the one end of the horizontal axis, *theories of social practice* focus on the production and reproduction of ways of engaging with the world while emphasizing social systems of shared resources. On the other end, *theories of identity* focus on the social formation of the person, the creation of membership and the formation of social categories. Wenger explains that on this horizontal axis learning is again caught in the middle since it ‘is the vehicle for the evolution of practices and the inclusion of newcomers while also (and through the same process) the vehicle for the development and transformation of identities.

While these theories form the main backdrop for Wenger’s work, he goes on to refine the picture by adding what he refers to as ‘intermediary axes’ (p.13). It is beyond the scope of this thesis to deal with these in detail but I mention them briefly because their influence is clear in Wenger’s work and, according to Wenger, the refined version (below) outlines ‘in a more detailed and rigorous fashion’ (p.14) what he considers to be the components of a social theory of learning.

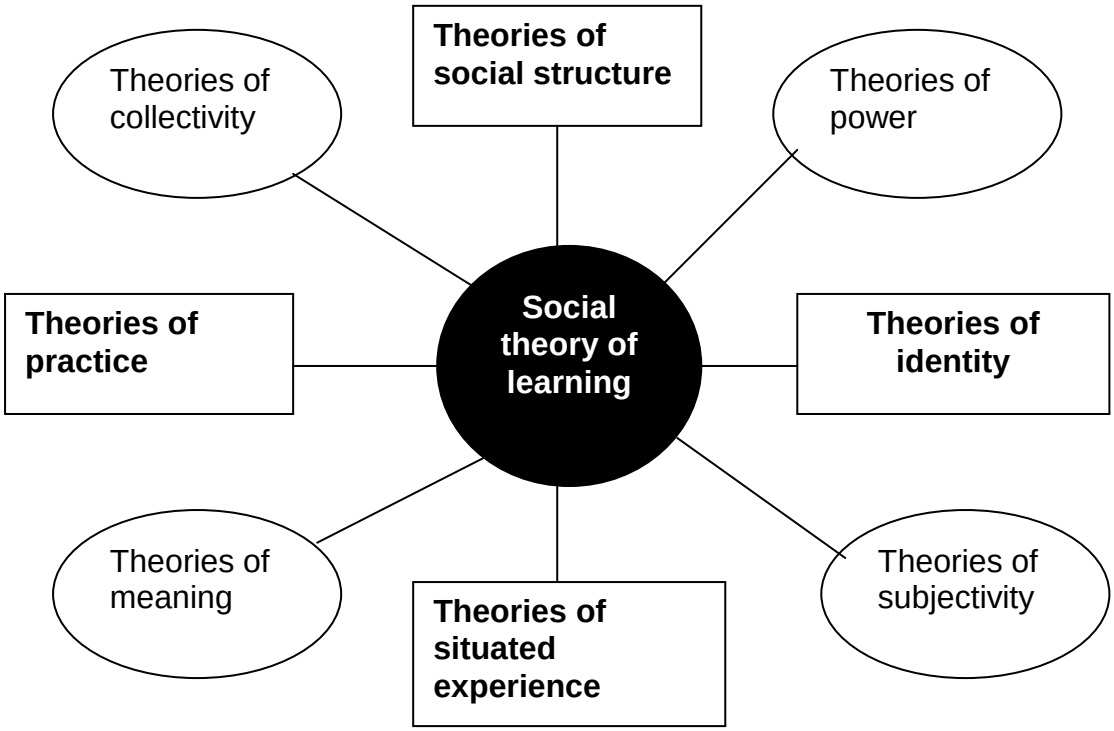


Figure 5.2 Refined intersection of intellectual traditions

It is drawing on all these bodies of work that makes Wenger's work particularly appealing and enables coherence with those parts of this study that deal with broader contextual factors such as issues of power, race and ethics and, more globally, ideological, political, economic and social transformation. However, Wenger clarifies:

> The purpose of this book is not to propose a grandiose synthesis of these intellectual traditions or a resolution of the debates they reflect; my goal is much more modest. Nonetheless, that each of these traditions has something crucial to contribute to what I call a social theory of learning is in itself interesting. It shows that developing such a theory comes close to developing a learning-based theory of the social order. In other words, learning is so fundamental to the social order we live by that theorizing about one is tantamount to theorizing about another (p.15).

Part 3: Elaborating Wenger's framework of learning

What does Wenger (1998) provide?

Wenger's (1998) book *Communities of Practice: Learning, Meaning, and Identity* provides a theory of learning in which the primary unit of analysis is neither the individual nor social institutions but 'communities of practice'. The theory explores systematically the intersection of the learning components: community, practice, meaning and identity and these provide a conceptual framework for analysing learning as social participation.

In the Introduction to his book, Wenger explains the aims and achievements of his earlier work with Lave but notes that the central concepts of identity and community of practice (to which I was most drawn) while central to their work 'were not given the spotlight and were left largely unanalysed' (p.12). Recall that in his earlier work with Lave the central defining characteristic of learning was the process of *legitimate peripheral participation*.

In his 1998 work Wenger moves away from a focus on *legitimate peripheral participation* (it is only mentioned twice in his book) to give a greater focus on the concepts of *communities of practice* and *identity*. Referring to his 1998 work he writes: 'In this book I have given these concepts centre stage, explored them in detail, and used them as the main entry points into a social theory of learning' (p.12).

Wenger (1998) explains that communities of practice are everywhere and because they are so informal and pervasive they are rarely focused on. Focusing on them allows us to deepen, expand and to rethink our intuitions. He relates communities of practice to the learning components of meaning, practice, community and identity as follows:

> On the one hand, a community of practice is a living context that can give newcomers access to competence and also invite a personal experience of engagement by which to incorporate that competence into an identity of participation. On the other hand, a well functioning community of practice is a good context to explore radically new insights without becoming fools or stuck in some dead end. A history of mutual engagement around a joint enterprise is

> an ideal context for this kind of leading-edge learning, which requires a strong bond of communal competence along with a deep respect for the particularity of experience. When these conditions are in place, communities of practice are a privileged locus for the *creation* of knowledge (Wenger, 1998, p.214).

Wenger's (1998, p.4) work is based on four premises:

1. That people are social beings is a central aspect of learning;
2. Knowledge is about competence with respect to 'valued enterprises';
3. Knowing is about active engagement in the world;
4. Meaning is ultimately what learning produces.

Furthermore, he emphasises that learning is inevitable since failing to learn something involves learning something else. However, he adds that reflection on learning, despite its inevitability, is important because:

> We wish to cause learning, to take charge of it, direct it, accelerate it… Therefore our perspectives on learning matter… It is our conception of learning that needs urgent attention when we choose to meddle with it on the scale which we do today (p.9).

Wenger's work on learning resonated with many of my common sense assumptions of learning and I too was compelled to reflect more systematically on these assumptions since I was directly involved in 'meddling' and 'taking charge of' the learning of teachers.

A focus on Wenger's four components of learning as a structural framework for analysis

I have already explained how the work of Lave & Wenger (1991) resonated with my experiences of teacher learning and my research aims of this study. I have also explained how their notions of communities of practice and identity particularly resonated with both my personal and research experiences of how learning took place. In the sense that Wenger's (1998) work extended his earlier work with Lave, it seemed reasonable to expect that his work would provide some support for developing a framework for the data analysis.

Wenger (1998) identifies four components of learning namely: *meaning, practice, community* and *identity*. These components of learning are defined as follows:

1. *Meaning* is a way of talking about our ability to experience the world as meaningful;
2. *Practice* is a way of talking about shared historical and social resources, frameworks and perspectives that sustain mutual engagement in action;
3. *Community* is a way of talking about the social configurations in which our enterprise is defined and our participation is recognisable as competence;
4. *Identity* is a way of talking about how learning changes who we are.

These four components together provide a structuring framework for a social theory of learning. Wenger (1998, p.5) summarises this framework in the following diagram:

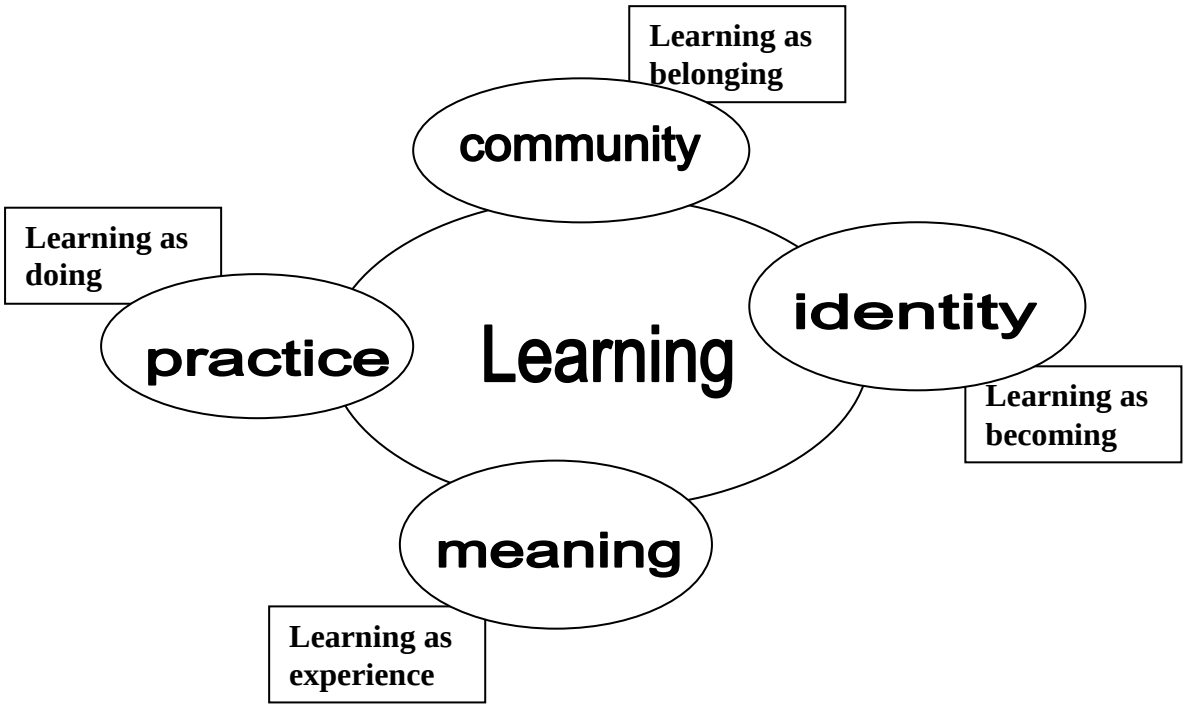


Figure 5.3 Components of a social theory of learning: an initial inventory

Wenger notes that the elements are 'deeply interconnected and mutually defining' (p.5) and points out that one could 'switch any of the four peripheral components with learning, place it in the centre as the primary focus, and the figure would still make sense' (p.5). Indeed this is the way in which I used Wenger's four components as a framework for analysing and describing teacher

learning in this study. When I focused on one component, it became the central focus, interconnected to and mutually defined by the other components placed temporarily on the periphery.

Thus it was the simplicity of this four-component 'model' of learning with its ability to capture the complexity of learning (through the interconnectedness and mutual definition of the components) and its provision of a structuring framework for analysing teacher learning within a community of practice (PLESME) to which I was most attracted as a structuring device for the analysis of the data.

In particular Wenger's four components of learning resonated with my analysis of the data on teacher learning during PLESME. These components were particularly useful in describing and explaining teacher learning in PLESME since they corresponded (almost on a one to one basis) with the primary recurring phenomena that were emerging from the data (see Chapter 4). These components, together with the component of 'confidence' that was entirely grounded in the data in the sense that its emergence was unexpected and not theoretically pre-empted, provided a powerful framework for describing, analysing and explaining teacher learning in a context of curriculum reform.

In the data analysis of Chapter 6 and Chapter 7, I use five aspects (components) of learning, namely *meaning, practice, identity, community* and *confidence* to frame my analysis of the data. I do so however in a grounded way in that while the intersection of the first four components is derived from Wenger, the way in which the components emerge from the data and are explored in relation to the data are specific to the context of teachers learning about South African curriculum change in PLESME. As expected, these learning components take on their own meaning in relation to this context.

In the data analysis I kept Wenger's diagram of the various components of a social theory of learning (Figure 5.3 above) close by. I regularly reflected on how a piece of data illustrated learning in relation to a particular component and how such data shed light on the relationships between the components. Since the purpose of the study was not to map Wenger's work onto my data I did not feel it necessary to draw on all aspects of his 'theory of learning' in my discussion of the data analysis. Thus while the complete work of Wenger (1998) and Lave & Wenger (1991) have clearly influenced the conceptualisation and design of the research, as well as having influenced the lens

through which I analysed the data, the most explicit use of Wenger's work in the data analysis is his four-component diagram of learning as a guiding framework for a more grounded analysis.

In an attempt to keep the analysis grounded in the data my use of Wenger's work was therefore relatively 'crude'. This is not to undermine my acknowledgement of the influence of his broader work (including his earlier work with Wenger) in providing the interpretive framework through which I analyse the data and in providing a language for describing teacher learning[1]. But rather to point to the importance of understanding that the process of data analysis involved dialectical movement between theoretically informed analysis and analysis that was more grounded in the data.

An additional point of clarification is needed in relation to where communities of practice fit in relation to Wenger's figure 5.3 'Components of a social theory of learning' above. According to Wenger's definition, communities of practice clearly involve all four components of learning. Wenger explains that his use of the concept of communities of practice was as a point of entry into a broader conceptual framework of which it is a constitutive element, and that the analytical power of the concept is that it integrates all four components. In this way 'communities of practice' is the primary unit of analysis in relation to his theory of learning.

As explained in Chapter 4, the primary unit of analysis for this study is not 'the teacher', nor 'PLESME', but the teacher- in- PLESME- in- the teacher. In this respect the community of practice of PLESME is primary and permeates the analysis of teacher learning in relation to each of the components of learning.

According to Wenger (1998) the following are indicators that a community of practice has formed:

1. sustained mutual relationships – harmonious or conflictual;
2. shared ways of engaging in doing things together;
3. the rapid flow of information and propagation of innovation;
4. absence of introductory preambles, as if conversations and interactions were merely the continuation of an ongoing process;

[1] Lave and Wenger's (1991), and Wenger's (1998), exploration of concepts such as *alignment, imagination, reification, participation, mutual engagement* and *negotiation* have been insightful and useful in the analysis of teacher learning in this study.

5. very quick setup of a problem to be discussed;
6. substantial overlap in participants' descriptions of who belongs;
7. knowing what others know, what they can do, and how they can contribute to an enterprise;
8. mutually defining identities;
9. the ability to assess the appropriateness of actions and products;
10. specific tools, representations, and other artefacts;
11. local lore, shared stories, inside jokes, knowing laughter;
12. jargon and shortcuts to communication as well as the ease of producing new ones;
13. certain styles recognised as displaying membership;
14. a shared discourse reflecting a certain perspective on the world (pp.125-126).

Since PLESME was a long-term INSET project in which teachers engaged regularly with the same group of people about mathematics education and new curriculum developments it was de facto a community of practice. That PLESME met the fourteen indicators above will be evident in the vignettes and quotes of teachers in Chapter 6 and Chapter 7. Furthermore, as will be shown in Chapter 6 and Chapter 7, the teachers invested in this community of practice because it became a part of their identities as teachers and 'a part of who they were'. Wenger (1998) writes:

> In a community of practice, mutual relationships, a carefully understood enterprise, and a well-honed repertoire are all investments that make sense with respect to each other. Participants have a stake in that investment because it becomes a part of who they are (p.97).

In the next section I provide a brief outline of Wenger's components of learning. I do not deal with each component in its entirety, nor do I follow the structure Wenger followed in describing his theory of learning in relation to these components. Indeed the structure of Wenger's book does not, as one would expect, follow from his diagrammatic summary (in Figure 5.3 above) of the four components of learning. His structure, stimulated by his vignettes in relation to apprenticeship contexts, is very different. This is discussed in Part 4 below.

Expanding on Wenger's four components of learning

Meaning

For Wenger 'meaning' deviates from its common sense definition and rather provides a way of talking about our changing ability to experience the world as meaningful. In this way meaning is understood as experience in relation to practice. Wenger writes:

> *Practice is about meaning as an experience of everyday life*. If the kind of meaning I am interested in is an experience, and if it is not the kind we can find in dictionary definitions or in philosophical discussions, then I need to address the question of where it is located and how it is constituted (p.52).

For Wenger, meaning is located in a process called *negotiation of meaning,* which involves the interaction of the processes called *participation* and *reification.* Wenger's use of the term participation is the same as its 'common usage' (p.55). It describes the 'social experience of living in the world in terms of membership in social communities and active involvement in social enterprises' (p.55).

> It (participation) is a complex process that combines doing, talking, thinking, feeling, and belonging. It involves our whole person, including our bodies, minds, emotions, and social relations (p.56).

Wenger uses the term reification 'to refer to the process of giving form to our experience by producing objects that congeal this experience into "thingness." In so doing we create points of focus around which the negotiation of meaning becomes organized' (p.58). Reification can refer to both a product and a process. Wenger writes:

> With the term reification I mean to cover a wide range of processes that include making, designing, representing, naming, encoding, and describing, as well as perceiving, interpreting, using reusing, decoding, and recasting (p.59).

These processes of participation and reification form a duality that is fundamental to one's experience of meaning and to the nature of practice. This negotiation of meaning is an active process of producing meaning that is both dynamic and historical, that participation describes the social experience of living in the world in terms of membership in social communities and active involvement in social enterprises.

In Part 1 of Chapter 7, I focus my analysis of teacher learning 'as meaning' in relation to teacher participation and reification during discussions (and in questionnaires) of the new curriculum and the mathematical outcomes. 'Meaning' is picked up in relation to teacher practices, teacher identities, teachers participation in the PLESME community of practice and overlapping communities, and teacher confidence in Parts 2, 3, 4 and 5 of Chapter 7 respectively.

Community

Wenger distinguishes communities of practice from other communities and points out that a residential neighbourhood, often referred to as a community, is not a community of practice. He associates *community* and *practice* together in a way that defines a special type of community. He notes that, because its terms specify each other, the term *community of practice* should be viewed as a unit. To associate the two, he describes three dimensions of practice that provide coherence to a community. These are mutual engagement, joint enterprise and shared repertoire.

As argued above, in that teachers participating in PLESME were involved in mutual engagement, participation in a joint enterprise and the development and use of a shared repertoire, the PLESME practice was clearly a community of practice. Furthermore PLESME can be considered to be a specific kind of community of practice, namely, a 'learning community' (Wenger 1998, p. 214). PLESME is considered a learning community because its explicit intention for all in the community was learning. Wenger notes that from his perspective on learning the focus of educational design should be on supporting the formation of learning communities. He emphasises that rather than viewing educational design as the cause of learning it should be viewed as a resource for learning.

As explained in Chapter 3 and Chapter 4, an intention in the design of PLESME from the start was to structure the INSET in such a way as to enhance teacher participation and collaboration with other teachers, and in so doing to form a 'community of practice'. This intention was based on the assumption that learning would be maximised by a supportive community. Furthermore, the

practices of PLESME overlapped with teacher participation in a range of other communities and indeed encouraged teacher participation in other communities.

In Part 4 of Chapter 7, I analyse teacher learning in relation to the teachers' alignment to and participation in PLESME and other overlapping communities. Five communities were identified as 'overlapping' with the PLESME community of practice in the sense that they provided essential support, challenge and extension to learning that was occurring in PLESME and in the implementation of new curriculum ideas and new teacher roles. These were the teachers' school communities, friends and family, local district communities and the AMESA community.

Analysis of teacher participation and multi-membership in overlapping communities is important as these communities provided critical support for teachers in becoming professionalised mathematics teachers. Wenger notes that communities of practice cannot be considered in isolation from other communities or from other practices since multi-membership in various communities is a critical source of learning since it forces alignment of perspectives.

Practice

In relation to Wenger's vignette of Ariel, a women working as an insurance claims processors, he notes that a practice is what Ariel and others have developed in order to do their job and have a satisfying experience of work. Similarly I would argue that practice in relation to this study is what the teachers in PLESME developed in order to do their job as teachers. In this sense, participation in PLESME was a part of doing their job as teachers, i.e. keeping up to date with new developments in education and being lifelong learners in relation to mathematics teaching.

Wenger (1998) describes practice as a shared history of learning and notes that practice is neither stable nor an object but rather an emergent structure. The emergent nature of practice is clear in Part 2 of Chapter 7 in which I discuss teacher learning as evolving practice. For Wenger, learning in practice includes the following processes for communities: evolving forms of mutual engagement, understanding and tuning their enterprise, developing their repertoire, styles and discourses (p.95).

Wenger argues that such a concept of practice includes 'the language, tools, documents, images, symbols, well-defined roles, specified criteria, codified procedures, regulations, and contracts'

(p.47) and also includes the 'implicit relations, tacit conventions, subtle cues, untold rules of thumb, recognizable intuitions, specific perceptions, well-tuned sensitivities, embodied understandings, underlying assumptions, and shared world views' (p.47).

In Chapter 3, I focused on describing and explaining the evolution of the PLESME practice and provided some insight into some of the resources (including tools, norms, social relations) of that practice. In Part 4 of Chapter 7, I discuss the PLESME practice and teachers evolving alignment and participation in the practice in relation to the PLESME community. For these reasons, in the data analysis in relation to learning as evolving practice (Part 2, Chapter 7), I focus on teachers' practices as professional mathematics teachers outside of, while still overlapping with, the PLESME practice. In Part 2 of Chapter 7, I therefore use practice in relation to both teachers changing practices in mathematics teaching and in relation to their changing practices in participation in education activities more generally.

Identity

As noted earlier the concept of learning as becoming is central to Wenger's work and indeed was an important focus of his earlier work with Lave. Since learning changes who we are, it is an experience of identity. Wenger explains that identity and practice are mirror images of each other. For example, if practice can be considered as negotiation of meaning, as community and as shared history of learning then identity can be respectively considered as negotiated experience of the self, as membership and as a learning trajectory.

Wenger (1998, p.149) characterizes the component 'identity' as follows:

- Identity as negotiated experience. We define who we are through our participation and by the way we and others reify ourselves.
- Identity as community membership.
- Identity as learning trajectory. We define who we are by where we have been and where we wish to go.
- Identity as nexus of multimembership. We define who we are by the way we combine our various forms of membership into one identity.

- Identity as a relation between the local and the global. We define who we are by relating our local ways of belonging to broader 'constellations'.

Teacher's changing identities and status in various communities were largely evident in relation to their changing *practice*. For this reason much of the analysis of teacher learning 'as changing identity' is subsumed in discussions of teacher learning 'as evolving practice' (see Part 2 of Chapter 7). In Part 2 of Chapter 7, I explore the relationship between teachers' mathematical histories and the implementation of new curriculum ideas and more learner-centred methods. In explaining this relationship I draw on Wenger's notion of learning trajectories. According to Wenger (1998):

> As trajectories, our identities incorporate the past and the future in the very process of negotiating the present… Learning events and forms of participation are thus defined by the current engagement they afford, as well as by their location on a trajectory (p.155).

In Part 2 of Chapter 7, I also explore the relationship between the contradictory official projected identities of the incoming Curriculum 2005, the outgoing performance-based curriculum (as discussed in Chapter 2) and the take-up of teacher roles and identities in relation to these projected identities. I therefore supplement my analysis of learning as identity with Bernstein's concept of official projected identity in relation to curriculum design and policy.

In Part 3 of Chapter 7, I therefore focus on teacher learning in relation to evolving *mathematical* identities. While I focus my analysis on the development of *mathematical* identities, the characteristics of identity as negotiated experience, community membership, learning trajectory, multi-membership and reconciliation of the local and global all emerge in relation to teachers learning to become professionalised mathematics teachers. The notion of a learning trajectory is especially useful in describing differences in the development of teachers' mathematical identities.

In summary:

Wenger's (1998, pp.226-228) social perspective on learning can be summarised by the following principles:

- Learning is inherent in human nature.

- Learning is first and foremost the ability to negotiate new meanings.
- Learning creates emergent structures.
- Learning is fundamentally experiential and fundamentally social.
- Learning transforms our identities.
- Learning constitutes trajectories of participation.
- Learning means dealing with boundaries.
- Learning is a matter of social energy and power.
- Learning is a matter of engagement.
- Learning is a matter of imagination.
- Learning is a matter of alignment.
- Learning involves an interplay between the local and the global: it takes place in practice, but it defines a global context for its own locality.

Part 4: Some challenges in applying Wenger's framework

In applying Wenger's four-component model of learning as a frame for the analysis of teacher learning in PLESME there were several areas of challenge.

First, since the four components of learning are so interconnected it was very difficult to deal with each component separately and inevitably a large amount of overlap occurs between the categories. Dealing with the components of learning, one by one in a linear fashion (as I have done i.e. meaning, practice, identity and community) is tricky since ideally these parts should be considered in parallel. Perhaps it is this difficulty that led Wenger to *not* structure his book according to the four learning components that he set out in the introduction of his book. Instead he divides his book into two parts: practice and identity (leaving meaning and community subsumed within discussions in relation to these).

In this study, despite the difficulties in relation to dealing with the components of learning separately and in a linear fashion, I have structured my analysis of teacher learning according to each component. In this way the nature of teacher learning is analysed in relation to each component and interrelations with other components are highlighted. The primary challenge of using Wenger's model however is not the organisation of the components in a systematic way that

simultaneously emphasises the interconnectedness of the model. It is rather the absence of a crucial learning component, namely, confidence.

Not only is confidence not considered as a component of learning by Wenger or Lave & Wenger, it is not considered *at all* in relation to the four components of learning. When first reading Lave & Wenger and Wenger this did not strike me as an obvious omission. However, when analysing the data of teachers in the second year of participation in PLESME, 'confidence' emerged as a crucial recurring phenomenon in both teacher descriptions and explanations of learning.

In this respect I had to ask why Lave & Wenger (1991) and Wenger (1998) had omitted to discuss confidence in relation to their emergent perspective on learning. Perhaps it is because the notion of 'confidence' is steeped in psychological traditions or perhaps the empirical studies informing their work were not of a sufficiently longitudinal nature for confidence to emerge as a central component of learning.

Since much of the literature relating to 'confidence' as a phenomenon of mathematics learning has been from a psychological perspective and has tended to focus on individuals, I was reluctant to draw from the literature to support my deeper analysis of the meaning of this increasing 'confidence.' I wanted to develop an understanding of confidence and its relationship to mathematics teacher learning from a socio-cultural 'learning as becoming' perspective and to explore what it meant in relation to Wenger's four components of learning (i.e. meaning, practice, identity and community). Since it is unexplored in the dominant literature in relation to 'learning as becoming' and 'learning as participation in practice' (Lave & Wenger, 1991; Wenger, 1998) and in relation to the application of such perspectives to mathematics education (see Watson, 1998), it begged further exploration within this theoretical framework.

In November 2000 I interviewed teachers on the emergent phenomenon of 'confidence'. Working in a grounded way I constructed a fuller meaning of this recurring phenomenon, and of what learning as evolving confidence means in relation to Wenger's perspective of 'learning as becoming', 'learning as doing', 'learning as belonging' and 'learning as experience' (see Chapter 6 and Chapter 7).

Due to Wenger's (1998) non-use of confidence as a central part of learning, I argue that his framework of learning does not deal comprehensively with all primary aspects of learning (in all

contexts). I believe that more work needs to be done (based on extensive longitudinal studies in a range of 'learning communities') in order to find a place for confidence in relation to this framework. For the purposes of this study I have used confidence as a fifth component of learning. Therefore, a contribution of this study is that it provides a start to theorising about the role of confidence in learning from such a perspective.

In Chapter 6 and Chapter 7, I draw on a range of data to illustrate the importance confidence played in teachers' learning as changing meaning, practice, community and identity. However, this is only a start. This work theorises learning as evolving confidence in one context and more work needs to be done in order to consider whether confidence should constitute a fifth component of learning in all learning contexts, or whether it should be subsumed within Wenger's four components of learning.

In this study I decided to use confidence as an overarching fifth component requiring discussion and analysis in its own right. This decision was partly based on its usefulness in relation to structuring the data analysis. Confidence, like meaning, practice, identity and community, was closely intertwined with all other components (discussed in Chapter 6 and 7). When considering positioning confidence in Wenger's diagram of the four learning components (in Figure 5.3 above) I was challenged to find a phrase to capture what confidence involves in relation to learning.

Wenger's four components each have a 'catch phrase' that captures what the component involves. For example, the phrase 'learning as belonging', captures the component *community*; the phrase 'learning as becoming' captures the component *identity;* the phrase 'learning as doing' captures the component *practice*, and the phrase 'learning as experience' captures the component *meaning* (see Figure 5.3 above). The challenge was to complete the phrase '*confidence*: learning as __?__'.

In relation to the data I had gathered, learning as belonging, becoming, doing *and* as experience all seemed appropriate for describing the component of confidence. It therefore made sense to place *confidence* as a fifth *overarching* component of learning. This led me to consider that if confidence in relation to teachers' learning to become professional mathematics teachers was about belonging, becoming, doing *and* experience then confidence might best be captured by the phrase 'learning as mastery'. I elaborate briefly.

‘Mastery’ is a word laden with various connotations, including problematic gender connotations. However, if indeed (as will be shown in Chapter 7) teacher confidence indicates that teachers in their learning achieved a level of ‘mastery’ in the practice of being professional mathematics teachers, then the concept contained in such a word is appropriate. In Part 5 of Chapter 7, I provide a range of evidence from teacher interviews that illustrate that teachers themselves related the component of confidence to their belonging to various communities, their becoming ‘mathematics experts’ in their communities, their participation in a range of mathematics education practices (in and beyond their schools) and their experience and knowledge of mathematics, mathematics education and the changing curriculum.

Furthermore teachers had mastered their profession to the extent that they were able to reconcile ‘mastery’ with understanding the limitations of what is possible to achieve within one’s profession and with the notion of lifelong learning. The following statements of teachers explaining their understanding of confidence, captures this:

> Confidence allows me not to have to know everything [Ivan Interview, November 2000]
> I can expose myself… I am willing to say Okay fine, show me wrong… What is your idea then? What I say is I am open. Let’s learn. That is what that self-confidence is… [Karl Interview, November 2000]

Thus mastery involves the insight to know when you don’t know, the confidence to admit to this, and the ability to access the necessary information (or experience) and support from the broader professional community of mathematics education (or other overlapping communities).

I argue that this alignment is crucial especially within the profession of teaching where experience, reflection and engagement with others is a key source of lifelong learning. Furthermore the profession of teaching will always be subject to adaptations relating to changes in broader education policies and the introduction of new curricula. In this respect being a professional mathematics teacher involves the ability to be adaptable to changing circumstances, new information and to be a continuous learner. Thus mastery of the profession of mathematics teaching involves a dynamic process of becoming a confident mathematics teacher in relation to the components of meaning, practice, identity and community. Furthermore, mastery of the profession of *mathematics teaching* involves mastery of particular epistemic demands relating to *mathematics* and *pedagogy*.

In this study I provide evidence to indicate that, like Wenger's four components of learning, confidence and mastery are both products and processes. The learners in this study were already practicing teachers with confidence in relation to some aspects of their profession. For many teachers however, limited mathematical histories, prevented them from experiencing mastery in relation to *mathematics per se*. In Chapter 7, I show that teachers both achieved further levels of mastery and continued with a process of ongoing mastery in relation to being and becoming professional confident mathematics teachers. In addition, I illustrate that confidence and mastery differed between teachers especially in relation to the epistemic demands of mathematics. This is discussed further in Part 5 of Chapter 7.

Another major challenge in Wenger's work relates to the dismissal of teaching as an important practice that results in learning. This is especially problematic when applying his work to teacher learning. As in the case of his earlier work with Lave, Wenger shifts the focus from teaching to learning. While this shift is particularly appealing for this study because of its focus on teacher learning, it does have implications for the development of *teacher* identities. What does it mean to be a teacher when it is argued that the practice of teaching should be minimized?

Furthermore, a view of learning that undermines the role of teaching is particularly problematic in the current context of curriculum change in South Africa. Many teachers have interpreted Curriculum 2005 and its emphasis on learner-centredness, co-operative learning and group work to mean that they do not really need to teach. Instead they should let learners, in groups, discover everything themselves. In some cases this provides a licence for teachers to withdraw from the classroom (after an initial activity is given) and in so doing the centrality of their role as teacher, facilitator and/or coordinator in guiding learning is seriously undermined. Without a detailed reconceptualisation of the practice of teaching from a 'community of practice' perspective, teachers and others are left to misinterpret the importance of a teacher's role in enabling learning which further demoralises the status of their profession.

While I agree that much learning takes place without intentional teaching and that much teaching does not lead to intended forms of learning, I do believe that in some cases even the most traditional forms of teaching have led to successful learning in terms of certain desired outcomes. Furthermore, to argue otherwise is to invalidate the work that teachers have done to date. In Chapter 3 I explained how at the start of PLESME I showed teachers snippets of their videos in

order to demonstrate that much of what they had been doing so far has been appropriate to new curriculum changes. The importance of this was to enable teachers to see that they had a solid base and a wealth of experience on which to build new ideas of teaching. Similarly I argue here that it is important that we do not 'throw out the baby with the bathwater'. Teachers have a wealth of successful teaching experiences that can be incorporated into a 'community of practice' perspective of learning.

While Wenger notes that learning may use teaching as one of its many structuring resources, his question of how to minimize teaching suggests that Wenger is dealing with a very narrow conceptualisation of teaching. I therefore ask: according to what definition of teaching should teaching be minimized? If we define teaching as the practice of teachers or by 'what teachers do' then depending on the teacher, the context, the content and intended outcomes etc., teaching could involve structuring a community of practice so as to allow learners access to resources in such a way that maximises learning. And this might involve drawing on a range of 'teaching methodologies' such as discovery learning, drill and practice etc.

In the sense that Wenger's work is an emergent perspective, I argue that this is an important aspect that needs further development. One cannot reject the centrality of teaching without first defining it. Wenger needs to first define the teaching that he feels should be minimized and reconceptualise 'good' teaching according to his perspective.

Wenger's avoidance of the concept of 'teaching' *per se* is likely to stem from the apprenticeship context from which his work developed. In this context there are no 'teachers' only 'masters' and therefore research is needed that considers the role of teachers in 'formal' learning contexts versus the role of 'masters' in apprenticeship or work based contexts (e.g. learning in the job). In his earlier work with Lave, Lave & Wenger (1991) argue that a decentring of common notions of mastery and pedagogy is necessary. They write:

> To take a decentred view of master-apprentice relations leads to an understanding that mastery resides not in the master but in the organisation of the community of practice of which the master is part… Similarly, a decentred view of master as pedagogue moves the focus of analysis away from teaching and onto the intricate structuring of a community's learning resources (p.94).

In the sense that a schoolteacher can be equated to a master in an apprenticeship practice (as is done in the quote above), we can deduce that a teacher's job is to organise the community of practice in such a way that learning is maximised. This 'organisation' by teachers in relation to their learners needs further exploration.

Wenger does not use the term 'master' in his 1998 work and fails to provide a thorough discussion of the central role of such a person in a community of practice or more specifically in a learning community. Perhaps this is because the development of his perspective is based on the vignette of Ariel's involvement in the practice of claims processing rather than on a person undergoing apprenticeship training or formal learning. The result is that much work needs to be done in order to translate Wenger's (1998) perspective on learning (based in the context of learning on the job) to learning in more formal education contexts where teachers (or facilitators, coordinators etc.) have a central role in ensuring that successful learning occurs and are furthermore held accountable for such learning. That is, the success of a their vocation depends on successful learning.

An interesting paradox occurs in relation to the coordinator of an INSET project being equated to a 'master' in an apprenticeship practice. The question arises: what teachers are being apprenticed into? Since the 'apprentices' are already practicing teachers, they are not being apprenticed into the practice of teaching (even though they are learning to become professional mathematics teachers). Rather teachers are apprenticed into the practice of being a teacher educator, if they so choose. A key difference is that this form of apprenticeship is seldom the intention of INSET and therefore is only taken up by some teachers, depending on their trajectories and career goals.

This paradox is summed up in a discussion between a PLESME teacher and myself (as coordinator of PLESME). Prior to this discussion Sam explained that he had been asked by an INSET organisation to apply for a position in the organisation of teacher educator.

> Sam: Only thing is working with PLESME and so on being exposed to all the other things, one just wonders if I am going to stay in teaching … PLESME is trying to create leader maths teachers not to leave the classroom but it works so great that I like think sometimes that I am outgrowing my classroom.

> MG[2]: Yah I mean to come to PLESME aims for me it is not something I would worry about… whether you at some point choose to be a leader where your main work is working with teachers rather than working with kids in a class I think both are great. My sadness would be if suddenly you were no longer in mathematics education… I get a sense that you are interested in moving into teacher education eventually. I don't see that as a loss for the profession… I mean I moved that way [Sam Interview, November 2000].

Just as Wenger (1998) avoids the notion of master he fails to engage with the notion of 'mastery'. 'Mastery' of the profession of mathematics teaching is clearly much broader than mastering the practice of teaching learners mathematics, or in Wenger's terms, successfully organising a community of practice in which mathematics learning takes place. Mastery, in relation to becoming a professional mathematics teacher, involves becoming *confident* in relation to: one's professional knowledge and experiences, one's participation in professional activities, one's membership in a range of professionally related communities and one's identity as a professional mathematics teacher. This is evidenced in Chapter 6 and 7. Thus mastery in the context of learning about teaching extends beyond the community of learners to the broader context of participation in other professional activities and communities.

The work of Wenger (1998) and the work of this study focus on how learning occurs. Both works describe and analyse *successful* learning. What is omitted are vignettes and discussions of what people failed to learn, those people who chose not to participate, those who chose not to become part of a community of practice. It seems that from this perspective it is easier to explain why successful learning occurs than to explain why it does not. Stein and Brown (1997) make a similar observation.

Stein & Brown (1997) apply Lave & Wenger's 'community of practice' perspective to teacher change stimulated by participation in an INSET project. They highlight several advantages of adopting Lave & Wenger's socio-cultural view of learning rather than a psychological perspective, but they also note that there are limitations in its application to situations in which intended teacher learning does not occur:

[2] MG refers to myself, Mellony Graven, as the researcher.

> Adopting a community-of-practice perspective to explain teacher learning may not be appropriate in situations where reform goals and joint productive activity have not taken hold (p.171).

Instead they suggest the use Tharp and Gallimore's (1988) framework to explain why teachers in certain situations do not form a community conducive to teacher learning. This framework draws on assisted performance in the Zone of Proximal Development is more appropriate. Both perspectives are rooted in a socio-cultural view of learning and both define learning as a process of transformation of participation.

In Chapter 4, I explained that early in the study three teachers dropped out of PLESME (and therefore out of the research sample). While it would have been useful to explain their non-participation in PLESME beyond their stated reasons of time pressures[3] this was complicated by the very same reality that they were no longer a part of the project. It was therefore highly unlikely that if they did not wish to participate in PLESME they would be willing to participate in *research* about their non-participation. Furthermore it would imply distrust for the teacher's stated explanation of the difficulty of time pressures. This clearly presents a dilemma for researching non-participation and unsuccessful learning, and creative forms of research need to be devised in order to gain access to useful data in this respect.

Related to the challenge to explore unsuccessful learning (i.e. learning something other than the desired outcomes or failing to learn the desired outcomes) is a dilemma that concerns what to look for when researching learning. When learning is based on a teaching curriculum, the success of that learning is usually judged in terms of assessing whether the intended outcomes of the teaching curriculum have been met. However, if as Wenger suggests we shift the focus from a teaching curriculum to a learning curriculum then it becomes difficult to pre-determine what to look for when judging the success of that learning. I reflected on this tension when discussing the work of Lave & Wenger (1991) in a reading group meeting:

> Kate and I were both however concerned about how you research learning without knowing what you are looking for. It is easy to research take-up in terms of a teaching curriculum because it gives you a guide as to what to look for. But if we accept that a lot more learning is

[3] There is some evidence in Chapter 7 that the non-participation of a math colleague of Karl (a PLESME teacher) was influenced by his lack of identity with teaching as a long-term career.

> happening than the intended objectives of the INSET then how do you know what to look for? Which learning is very important and which is not? This will be a limitation of my research but it is an unavoidable one. I will only be able to see learning in terms of what teachers give me access to, what learning I am able to identify and this will be influenced by what I read, who I am etc. [Journal, July 1999].

While I agree with Wenger that failing to learn something involves learning something else, this does not make it any easier in identifying how, why, and when individuals (and in this study teachers) learn something else.

It is beyond the scope of this study to elaborate and explain cases in which successful learning did not take place. There are nevertheless some promising movements in this direction. For example, Boaler & Greeno (2000), drawing on the work of Wenger and others[4], explain that many students while capable of mathematical practices reject them because these practices run counter to the development of their identities. They write:

> When students talked about their rejection of mathematics, their reasons went beyond cognitive likes and dislikes, to the establishment of their identities. They talked not about their inability to do the mathematics, but about the kinds of person they wanted to be (p.187).

This work draws primarily on *identity* as an explanation for why students fail to learn the desired learning outcomes (that is their learning is unsuccessful in relation to these outcomes) and instead learn something else (for example they learn that they do not belong to a specific community and they do not identify with the practices).

Conclusions

Above I have explained how and why the work of Lave & Wenger (1991) and Wenger (1998) came to influence this study. I have elaborated on those aspects of their work that particularly resonated with the study and have critiqued their work in relation to its applicability to the context of teacher

[4] Most noteworthy is the work of Holland *et al.* (1998).

education. In particular, I have taken issue with the absence of the notion of confidence in their work, which as this study shows (see Chapter 6 and 7), is a central phenomenon of learning.

The primary aim of this study is to investigate teacher learning in PLESME in the context of curriculum change. In Chapter 6 and Chapter 7 I provide detailed descriptions and explanations of teacher learning that are grounded in the data. While these chapters exemplify aspects of Lave and Wenger's (1991) and Wenger's (1998) perspective on learning they do not 'test' all aspects of their work. Rather the chapters shed light on those aspects of their work that emerged in the context of teacher learning in PLESME.

In particular, Wenger's four components of learning: meaning, practice, identity and community emerged strongly from the data, and are therefore used to frame the analysis. Since confidence emerged strongly from the data as a central to learning it is added as a fifth component and is used with the other components to frame the analysis. Thus Chapter 6 and Chapter 7 shed light on the strengths and limitations of applying Wenger's components (and the theoretical perspective from which they are derived) to the context of in-service teacher education.

What follows is an analysis of teacher learning involving dialectical movement between a grounded approach to the data and theoretically informed data analysis and theory generation.

Chapter 6: Establishing that teacher learning occurred: An illustrative narrative vignette as a prelude and frame for further analysis

During the course of the two-year period of PLESME it was clear that learning had occurred for all teachers. This was evident from both what teachers said and did in relation to their changing practices. Teacher practices were different in relation to: 1) the way in which they talked about (and made *meaning* of) teaching and the purposes of the new curriculum 2) their teaching *practice* in the mathematics classroom 3) in their participation and status *(identity)* in various *practices* in, 4) a range of *communities* related to their profession, and 5) in their *confidence* in participating in practices.

These highlighted terms are the four components of learning as identified by Wenger (1998). As outlined in Chapter 5, 'confidence' is not dealt with by Wenger but forms a major part of this thesis as it emerged strongly from the data. All of the above changes are closely interrelated as will be illustrated in the analysis that follows.

Changes in each of the above features were evident for all teachers. In order to illustrate with some richness and texture the nature of such change, I have chosen, in this chapter, to provide a more in depth narrative vignette of one teacher.

This in-depth vignette serves as a prelude to the chapter and provides the basis for theorizing the frame for the data analysis that follows in Chapter 7. For this reason it is necessarily lengthy and 'thick' with description. The vignette is constructed from a range of data sources, namely three sets of interviews, questionnaires and classroom observations conducted at different points over the two-year period. These data sources are discussed in detail in Chapter 4. The purpose and use of narrative vignettes for this research was also discussed in Chapter 4.

The narrative vignette of Ivan exemplifies the nature and complexity of teacher learning in relation to PLESME and curriculum change. I have used selective transcripts from interviews, questionnaires and classroom videos to provide richness and texture to the story I tell. I have italicised sections of the transcripts where they are particularly illustrative of the analysis I am drawing from them. As Brown & Dowling (1998) argue, selection is inevitable and proper in all

research. The selection of narrative vignettes and quotes provided in this chapter and in Chapter 7 has been influenced by the overall purpose and theoretical perspective of this study.

Narrative vignettes could have been constructed for each of the teachers and these would demonstrate similar changes over time in respect of the *direction* of change in the five areas listed above. That is, for all teachers there was evidence of *increased* ownership of 'new' ways of talking about teaching and the new curriculum, *increased* use of more learner-centred methodologies and engagement with mathematical meanings in teaching, *increased* participation in a wide range of school and community activities, *increased* status and personal identity as a competent professional and *increased* confidence in their ability to participate in a range of practices.

Of course this is not to say that all stories would be the same and indeed the data reveals many differences in the speed and nature of change between teachers in the above five areas of change. In Chapter 7, I explore the major recurring phenomena that emerged for teachers in relation to their learning and focus on the similarities and differences across the teachers. In this chapter I describe in detail the process of learning for one teacher, Ivan.

A narrative vignette of Ivan

Ivan is a primary school mathematics teacher. At the start of 1999 he taught in a relatively well-resourced school in Soweto. Prior to 1994 all government schools in Soweto were run by the Department of Education and Training. Such schools therefore received less funding than schools in white, coloured and Asian areas. By 1999 the racially segregated departments of education were replaced by provincially defined departments within a single National Department of Education. However, many schools in 'traditionally disadvantaged areas' (including Ivan's) were still without basic resources such as textbooks and photocopying facilities.

In June 1999 Ivan moved to a less well-resourced school in a poorer part of Soweto where he took up the position of the General Sciences Head of Department. Once again resources such as textbooks, learner books and photocopying facilities were scarce. In both schools learners were black, from very poor homes (including from the informal settlements nearby) and almost all learners were second or third language English Speakers.

In such 'township' schools repeating after teachers (chanting) and rote type learning was common practice. It was also common for learners and teachers to treat resources such as textbooks and writing books as precious commodities only to be used under strict supervision and only for 'neat' work. Such work often involved copying definitions or examples from the board. In general there was both a lack of resources and an under-use of available resources (Taylor & Vinjevold, 1999).

Ivan had no formal teacher training and had not studied mathematics since school. He had a Diploma in Information Technology. At the start of 1999 Ivan had been teaching mathematics for nine years.

Part 1: Making meaning of the curriculum change

In January 1999, interviews were held with all PLESME teachers prior to the commencement of PLESME workshops. The interviews asked teachers a range of questions from their understanding of the new curriculum to what they were hoping to gain from participation in PLESME (see Appendix 5). At the start of 1999 Ivan explained that he was insecure about the new curriculum but was still open to learn about it:

MG [1]: What are your views on the new curriculum?
Ivan: The new curriculum basically I am *not just yet conversant* with it because they have started with the smaller grades so *I am not as yet sure about it*, but all I have heard is that it basically is that the teacher facilitates the learning right, but it doesn't mean the children are blank, but you should take their background into cognisance … Like I said *I don't know much about it, I am still waiting to be trained. I am still open minded about it* but if the policy states that no child fails or something like that *then I don't know*…

The final sentence of the above quote shows that while Ivan is open to the curriculum change he is concerned about how it will impact on the assessment of learners. Some curriculum support documents issued by the National Department of Education indicated that 'there will be no passing or failing' (NDE, 1997a, p.19). With schools still needing to ensure good results in the external grade 12 examinations, and with a focus by Ivan's district advisor on common external assessments for all learners in Ivan's school, it is understandable that he is concerned about this idea.

[1] MG refers to myself, Mellony Graven, as the interviewer.

While Ivan identified with the political aims of the new curriculum, he was unable to make mathematical sense of what the new outcomes relating to social, political, cultural and economic factors meant. The passage below (as transcribed from the interview) provides evidence of this:

MG: So specific outcome three says that learners must be able to demonstrate understanding of the historical development of mathematics in various social and cultural contexts, and the fourth one says that learners must be able to critically analyse how maths relationships are used in social, political and economic relations and the eighth one says that learners should be able to analyse natural forms, cultural products and processes as representations of shape, space and time…When you read that what do you think or feel about them?
Ivan: I think it is basically an attempt to link mathematics to what children can relate to, in their past, their present and what they could expect, something like that. I think in a way it is attempting to make the mathematics real to children in having *to analyse relationships using social and economics I would say, political I am not sure if they could relate to that yet. Historical development and cultural context I think they are objects which culturally they can link up with their shape, geometric sense or mathematical sense. I think it is good in that sense*.

The views expressed by Ivan reflect the broader context of political change and the difficulties of implementing Curriculum 2005 as discussed in Chapter 1. Ivan's support for the political motives behind introducing specific outcomes 3, 4 and 8 are clear but it is equally clear that he has had little support from the department in making sense of these outcomes and that he is stifled by 'complex and jargonised' (Jansen & Christie, 1999) language of the outcomes.

Six months later in a second interview (see Appendix 5) Ivan no longer made statements of insecurity in relation to talking about or making sense of the new curriculum. In talking about the new outcomes Ivan provided some examples of what they meant for mathematics teaching. For example, in relation to Specific Outcomes 4 and 8, Ivan responded:

Ivan on SO4: (rereads the outcome) critically analyse how mathematics relationships are used in social, political and economic relations (pause).
MG: Anything that comes to mind
Ivan: Okay, I think this outcome can prepare you socially speaking Okay in terms of businesswise right? The *handling of money, profit or loss*, Okay I think economically as well it also tailors to that business wise. Politically, politically I learnt that in the old system matric was manipulated according to the how many students must pass that was manipulated economically by the old regime you know like how many black kids can this market accommodate, something like that. Aah Okay. *Socially the scores like in cricket how they are used, like in soccer, Okay I think there is maths involved there,* and *Data* and so forth.
MG: Okay, the 8th outcome?

Ivan on SO8: (Reads the outcome aloud) Analyse natural forms and cultural products, processes as representations of shape space and time. Is it art?
MG: Whatever you think…
Ivan: (pause) if it's a cultural product I'm thinking of the art form you know. The art form in terms of calabashes I think the shapes, the *Ndebeles how they paint them I think there is a pattern that they follow there, (inaudible) like the Zulu like the necklace*, like the numbers when a man meets a women a women returns her love by putting something on a man, those colours they speak they follow a certain pattern, aah, shape space and time, I learnt the sun, the older people they look at the sun and they can tell you approximately what time of the day it is and stuff like that. And then shape, some other cultural products you can tell from which nation they are from by looking at their art you know the art expresses an integral part of the culture. *Right you can identify which nation is there…. I also remember something from the workshop where you said there was some research about patterns in nature,* something like that, that comes to mind. The pattern of flowers, that kind of thing. Also *in listening to music there is a pattern, you find out that maybe after so long the beat comes again, after so long the beat comes again, I think it is cultural as well. Even poems, music, and so on, has a kind of pattern*. Geographically, *the sun the moon, the sun taking so many days revolving, the moon, it's a pattern, it's time*. Scientifically I also learnt that, I learnt that in Standard 8 in a Science book they used an echo if it bounces back they can tell *how deep is the ocean.* I am trying to remember that. It bounces back and they can tell how deep is the ocean and so forth [Ivan Interview, June 1999].

Ivan provides a range of examples in the above explanation of Specific Outcomes 4 and 8. These examples are drawn from Ivan's experiences (for example, his experience of learning Science at school) and a range of resources that became available to Ivan through his participation in PLESME. These include ideas generated during PLESME workshops and ideas that he obtained from newly published textbooks provided in PLESME. For example, the Fibonacci pattern found in flowers was discussed in a PLESME workshop and Ivan found the idea of patterns in music in a newly published textbook. Ivan does not however expand on the mathematics inherent in the examples he provides.

In the final interview of November 2000 (see Appendix 5), Ivan again provides examples in his explanations of the outcomes but in addition specifies the mathematical content of some of those examples:

Ivan on SO4 & SO8: Analyse maths related to politics, like elections, *how numbers are manipulated* and populations as well, socially how they are used in sports and games, you know? Okay? Economically, okay, the value of money, *the currency of the Rand compared to the Dollar*…Okay natural forms…Okay, we are thinking in architecture, perhaps buildings, (interruption)… I was saying that buildings as well, *understand that triangles strengthen them*…trying to figure out in what way orientation and driving, judging can I drive through or not. I imagine that. *Judging spaces*, cars of this height can drive through, cars with bigger heights cannot… Like rainfall, rainfall like the big squares on a tortoise, Okay *like temperatures etc. Melting points, boiling points* like that [Ivan Interview, November 2000].

While the mathematics inherent in the examples Ivan provides is not expanded on it detail, Ivan does give us some idea of the mathematics involved. For example, rather than simply stating 'architecture' as an example, Ivan expands that this involves an understanding of how triangles strengthen buildings. It is interesting that the examples Ivan provides are in general not expressed as examples from his teaching experience. Other teachers in PLESME drew increasingly (between the first and the last interview) on their teaching experience to explain the outcomes. This is evidenced in Part 1 of Chapter 7.

Ivan's changing way of talking about the outcomes is indicative of his increasing ability to experience the outcomes as meaningful and his increasing confidence in talking about the new curriculum.

Part 2: Changing classroom practice

In response to how Ivan felt about the outcomes in June 1999 he responded positively by saying:

The outcomes are good in that they make one aware of what you are doing and what you want to achieve at the end with your children. But the main thing is to be clear where you want to go, what in fact you want to achieve at the end of the day unlike when you are just randomly you know approach. [Ivan Interview, June 1999]

In explaining what Ivan learnt from the INSET course Ivan said:

I think it (participation in PLESME) has brought some awareness in terms of *understanding maybe the theory around the child*, how the child perceives things…and the different kinds of children you know? Their perception as well is not the same, slow child and fast learners, they grasp quickly and how to accommodate both. And in terms of language, the difficulty of language it is helpful to note that sometimes you ask a question and the child understands it different to you whereas that is not what you meant. So it has made me quite comfortable with the results. Sometimes you are so obsessed with the results of the children, if the child doesn't get a certain result you think the children are stupid or you have failed but it has made me to understand that maybe they misunderstood me or maybe I didn't do that and that so it has made me *to look at myself critically and strive to do the best. It has also sort of made my teaching experience to be quite challenging as well*. And also to listen to children their thoughts, it's interesting to listen to what they think, sometimes the child's answer is different, it is interesting to listen to what they think. Y*ou learn as well* I think that is about all [Ivan Interview, June 1999].

In explaining how Ivan's classroom practice had changed he said:

I think I've now managed to hold their interest sometimes they are not even aware when times up, you will hear the next teacher knocking on door. Yaah it means that the lesson was interesting. Many ideas now come to mind how one can approach a lesson. If one approach fails you think of the next (inaudible)… [Ivan Interview, June 1999]

In the interview above Ivan explained how his access to resources such as knowledge of theories of learning, critical reflection of his teaching practices and an increased repertoire of approaches to lessons and learner centred practices made his teaching experience 'to be quite challenging'. He also explained that he himself was learning. By November 1999, Ivan's increase in confidence in relation to the new curriculum and teaching was evident. He now described his teaching as an 'exciting experience' and explained that some approaches that he had not used before were now an 'integral part' of his lessons:

The teaching has *become more exciting* for both my pupils and myself…There are various forms of approaches that I have overlooked and some which I didn't know of but which *now form an integral part of my lesson* approach for instance the use of newspapers in Mathematics; involving pupils in different activities in order to achieve different outcomes [Ivan Questionnaire, November 1999].

The above quotes indicate clear links between Ivan's changing understanding and ability to make *meaning* of new curriculum ideas and his changing teaching *practice*. Similarly, in the questionnaire of July 2000 Ivan explained that his participation in the PLESME community made 'teaching to be an exciting experience, it offers different perspectives and new approaches to mathematics'. He explained his difference in classroom practice by talking about his increased confidence and his changed identity/image in relation to his learners and parents:

I have *more confidence* in presenting the subject and in asking questions that are *exciting to pupils. The children love my subject* because it is not monotonous, *they always look forward to my next period*. When *children tell you that they enjoy your subject* and their results are improving and you also get *positive feedback from the parents* it is very encouraging [Ivan Questionnaire, July 2000].

These *stated* changes in classroom practice, in terms of a broader repertoire of approaches to teaching, more learner-centred practices and Ivan's increased confidence, are supported by classroom observations. Classroom observations, videos and reflection sessions were conducted at three different points throughout the INSET. Video recordings, observation schedules and detailed notes were taken of each of the lessons. Below, I have provided a brief analysis of each of Ivan's

lessons in relation to two main aspects of the lesson that is the mathematical content and the style of the lesson.

Of course there is much more that can be told about any one lesson and I have obviously made selections as to what is included. My selection is focused on the mathematical content of lessons and the style of the lesson (especially as it relates to the intersection of learner-centred practices with engagement with mathematical meaning) for the following reasons: these are the primary changes noted in teaching practice both by myself as the researcher and by Ivan; the development of more learner-centred practices and engagement with mathematical meaning is a focus of the new curriculum and was a focus of the INSET; and finally because the focus of this study is on *mathematics* teacher learning in relation to new *mathematics* aspects of the new curriculum.

Note: I am using Cuban's (1993) notion of 'learner-centred' versus 'teacher-centred' practices' as a tool for describing some of the changes (movement) in relation to Ivan's style and methods used in classroom practice. That is according to Cuban the following features are indicators of the two practices:

Indicators of Teacher-centred Practices	**Indicators of Learner-centred Practices**
• teacher talk exceeds learner talk • instruction is frequently whole class • use of class time is largely determined by the teacher • the teacher relies heavily on the textbook. • the class arrangement is typically rows of desks facing the board	• learner talk exceeds or equals teacher talk • most instruction is individual or small group • learners help choose the content to be learnt • learners determine partially or wholly the rules of behavior • there is a use of varied instructional materials • the classroom arrangement permits learners to work together

All three of the lessons observed were with Grade 7 classes.

Ivan's first lesson observation - 2nd March 1999

The lesson involved naming different polygons (e.g. rectangles, squares, triangles, parallelograms and trapeziums) and discussing their properties. Ivan's stated purpose of the lesson[2] was for learners to know polygons by their number of sides and associate them with things they know. He put some pre-cut shapes on the board (a triangle, rectangle, square and a parallelogram) and asked learners to name each shape, say where they had seen them before and give some of the properties of each shape.

Such properties were dealt with randomly. For example, in the case of the rectangle, Ivan discussed opposite sides being equal but did not discuss opposite sides being parallel (see the first extract below). In the parallelogram he discussed the parallel property of the opposite sides but did not discuss the equality of the opposite sides (see the second extract below).

Ivan did not require learners to name all the properties of each shape nor to point to what was similar between the shapes. He distinguished rectangles from squares by saying that in rectangles *only* two opposite sides are equal (meaning two opposite *pairs* of sides) and in squares four sides are equal (see line 4 below). Ivan therefore implied (and from the interview he clearly believed) that squares are not rectangles.

Ivan noticed that a learner was unsure about what 'opposite' meant in relation to the sides of a rectangle (lines 5-6). He clarified this by relating its meaning to 'opposite houses' (lines 9-11). He allowed learners to use the word neighbours to refer to the people who live in the house behind theirs but did not clarify the position of the houses of other 'neighbours' through using words like next to, adjacent or diagonally opposite. Such a discussion would have helped to clarify the position of other houses and could have then been drawn in to clarify the distinction between 'opposite sides' and 'adjacent sides', and, 'opposite angles' and 'diagonally opposite angles'. The absence of such a discussion created a problem later in the lesson (see the second extract, line 27).

[2] Reflection sessions were conducted with each teacher after each observed lesson. In such sessions teachers explained the purpose of their lesson. We would watch the video and the teachers and myself would be given a chance to comment on the lesson. Notes were taken about the content of the reflection sessions. In this first reflection we mainly dealt with the misconceptions that arose from the lesson and Ivan had very little to say about what he noticed from watching the video.

First extract from the lesson:

Ivan draws a rectangle and a square on the board.

1. Ivan: What's the difference between this shape and that shape? Yes Cristina?
Learner: The rectangle has two opposite sides equal.
2. Ivan: 2? 2 opposite sides which are equal. (Pointing to the square) What about this one?
Learner: All sides are equal.
3. Ivan: All the sides, this is important ne? All the ?
Class chorus with him: sides are equal.
4. Ivan: All the four sides are equal whereas in the rectangle its only the two opposite sides (pointing to the rectangle) only the?
Class chorus: two opposite sides
5. Ivan: When we say opposite sides what do we mean opposite? What do we mean opposite, when we say opposite? Somebody doesn't understand what you're talking about. What's opposite?
Learner: Equal
6. Ivan: Opposite means equal? He says..
Class chorus: No
7. Ivan: Why do you say no? What does opposite mean? Maybe you don't even understand
Learner: They are facing each other.
8. Ivan: They are..
Class chorus with him: facing each other. They are facing each other
9. Ivan: These that are facing each other. Which houses is opposite to your home? Mm? Which house is opposite to your home? Which opposite side? There is no opposite side? There is no house facing your home? You don't have neighbours heh? Which house is opposite to your home? No opposite house? Lucky?
Learner: The house on the back is opposite.
10. Ivan: Who lives there? Who lives there?
A few learners: Neighbours
11. Ivan: Who are they, friends maybe? Laughs He doesn't make friends with his neighbours. Okay as long as you understand what opposite means. It means the sides facing each other.

Ivan then focused on the (non rectangular) parallelogram that he drew on the board. He focused learners' attention to the opposite sides being parallel and on the obtuse and acute angles (lines 1-6 below). He then drew attention to what for him was the main difference between a rectangle and a parallelogram. That is that in a parallelogram there are no right angles (line 7 below). He continued by drawing a trapezium (of this shape [_\) and asked the learners what they saw (line 8). One learner saw a triangle (indeed it was possible to break the trapezium that he drew up into a rectangular part and a triangular part consisting of a right angled triangle). Ivan responded by

pointing to the equilateral triangle that he had on the board and asked the class in disbelief ‘you see a triangle?’ and the class responds in chorus ‘no’ (line 13). The child was not given a chance to explain rather Ivan asked ‘Are you sure of what you saw?’ and then immediately moved onto another learner in search of a ‘better’ answer that matched his own perception (line 14).

In this way the child’s thinking was invalidated and the learner’s perception was not understood or examined. Ivan ended this part of the lesson with a summary that all the shapes on the board with four sides are called quadrilaterals (lines 25-26).

Second extract from the lesson:

Ivan pointed to the (non-rectangular) parallelogram he had drawn on the board.

1. Ivan: It has two pairs of parallel lines ne? These (pointing to a pair of opposite sides) are also parallel ne? So that gives us the name for of the shape: Pa-ra-lello-gram. Where the name is derived from the parallel lines because of the ?
Class choruses with him: parallel lines
2. Ivan: and now we say something about the angles. We say that angle is obtuse (pointing to an obtuse angle on the drawing). (Pointing to another obtuse angle on the drawing) What about this one?
Class: Obtuse
3. Ivan: (Pointing to an acute angle on the drawing). That one?
Class: Acute
4. Ivan: (Pointing to an acute angle on the drawing). That one?
Class: Acute
5. Ivan: (Pointing to an obtuse angle on the drawing). What about this one?
Class: Obtuse
6. Ivan: (Pointing to an acute angle on the drawing). This one?
Class: Acute
7. Ivan: Whereas in the rectangle all the four angles are right angles. Right? Here there are no right angles. There are no?
Class choruses with him: right angles. There are no right angles.
8. Ivan: Are we together? Right let me introduce you to another shape as well that is going to puzzle you. What shape would you say this is? (Ivan puts a pre cut trapezium of this shape [\ on the board. What can you tell me about this shape? Okay, what can you tell me about this shape? What can you tell me about this shape ne? When you look at it what do you observe? When you look at that shape, when you look at that shape what can you tell me? I don’t want the name the name of the shape I just want what do you observe when you look at the shape, what do you see when you look at the shape? Yes?
Learner: The sides are not equal.
9. Ivan: The sides are note equal

Class chorus with him: The sides are not equal.

10. Ivan: That's very important ne? The sides are not equal, this side is not equal to this side, all the sides are not equal ne? What else can you tell me, what else can you tell me about the shape? Yes I'm tired of seeing the same hands all the time. What about others, don't you have eyes? What's wrong with you hey? Dlamini? What else can you tell me? Dlamini, stand up. Tell me something that you see there and tell me if you don't see anything as well. What?

Learner: I see a right angle.

11. Ivan: How many of them? She sees a right angle and she see only one?

Class: No

12. Ivan: Which one did you see, the top or the bottom (pointing to the two right angles in the drawing). So it has two right angles. What else? What else, someone else? What else? Tshabalala?

Learner: Triangle

13. Ivan: (Emphasis on underlined words) You see a triangle, a triangle you see something like this?! Here?! (pointing to the equilateral triangle shape on the board).

Class: No

14. Ivan: Heh, you see three angles here and you see three sides here? Heh!. What do you say? Heh! Tshabalala? Are you sure of what you saw? Lucas?

Learner: Acute angle

15. Ivan: Right come and show me an acute angle

Learner comes to the board and points to an acute angle on the drawn trapezium.

16. Ivan: Right he says this one (pointing to the angle the learner pointed to) is he correct?

Class: Yes

17. Ivan: What else do you see?

Learner: An obtuse angle

18. Ivan: Right come and show me.

Learner comes to the board and points to an obtuse angle on the drawn trapezium.

19. Ivan: Right are we through with the angles?

Class: No

20. Ivan: What else, Yes?

Learner: If you continue this line and that line they will meet.

21. Ivan: Oh she says this line (pointing to the vertical line) and that line (pointing to the 'skew' line \) if continued they will finally meet. So what does that tell us about the lines? What does it mean? This one vertically goes that way and this one goes a bit skew. They will finally converge. They will finally meet. What does that tell us? They are not?

Class chorus with him: Parallel

22. Ivan: They are not?

Class chorus with him: Parallel

23. Ivan: Now this kind of shape we call a tra..

Class chorus with him: pezium

24. Ivan: We call it a?

Class chorus with him: Trapezium

25. Ivan: A trapezium (he writes the word ‘trapezium’ on the board). Now all of these shapes we have discussed. Okay these that we have discussed, these that have four sides neh? They have one common name right? We call them quad?
Class chorus with him: ri laterals
26. Ivan: (Writes the word ‘quadrilaterals’ on the board) They are called?
Class: Quadrilaterals

Ivan then got learners to join the ‘opposite angles’ (as he called them although he meant the diagonally opposite angles) of the parallelogram. A learner came to the board but could not proceed since according to her perception of opposite angles, the opposite angles of the rectangle were already joined by the sides of the parallelogram. This perception of opposite angles was consistent with Ivan’s explanation of ‘opposite houses’. Ivan was unable to clarify what he had meant by ‘opposite angle’ and simply said:

27. Ivan: I am not satisfied that you know what opposite means.

The learner was not given the opportunity to explain her difficulty and Ivan immediately moved on to get another learner to come and try. This learner drew in a diagonal.

Ivan wanted learners to draw the diagonals and thus to join the *diagonally opposite* angles but he was unable to draw on such terminology to gain conceptual clarity on the meaning and difference between terms such as ‘directly opposite’ and ‘diagonally opposite.’ He continued to get learners to draw diagonals on the shapes on the board. This activity was not integrated with the properties of the shapes and was dealt with as an activity in its own right. The lesson ended without activities for learners to work on.

Commentary on the mathematical content of the lesson:

Mathematically the lesson dealt superficially with the naming of various four sided shapes and some of their properties. Since this was a Grade 7 class, it can be argued that there was no mathematical challenge to learners in the lesson but rather a recall of what they knew. The mathematical skill of classification was dealt with superficially (i.e. all shapes with four sides are quadrilaterals).

While there was a focus on the difference between shapes, the similarity between shapes, which would be useful for understanding inclusivity in classification, was not dealt with. For example, the

fact that squares are also classified as rectangles and that both are included in the classification of parallelograms was not dealt with and indeed could not be dealt with due to Ivan's own misconceptions.

Commentary on the style of the lesson:

The style of the lesson was very teacher-centred. Ivan controlled all interaction (as is clearly evident in both extracts above). There was no opportunity for learners to work independently or to engage in discussion with one another. Learner activity involved repeating after the teacher, responding to teacher questions which usually required brief answers involving: factual recall (e.g. how many sides do you see?), yes or no answers, describing what learners saw etc.

Occasionally learners were called to the board to point to their answer (e.g. lines 15-16 in the 2nd extract above). Engagement with learner answers only occurred when answers were 'correct' (e.g. lines 14-16) above. Ivan occasionally asked learners why they gave the answer they did and a brief explanation would follow (for example, Ivan: 'Why do you say it's a rectangle?' Learner's answer: 'Because the two opposite sides are equal'). There was a notable absence of questions requiring learners to explain their understanding, of challenging questions and an absence of dealing with learners 'incorrect' answers.

When learner answers were seen by Ivan to be incorrect (for example when a learner in the second extract saw a triangle in the trapezium and when a learner understood 'opposite angles' to be different from 'diagonally opposite angles') Ivan would communicate to the learner that the answer was incorrect (e.g. line 27) and would move onto another learner to provide a 'correct' answer that Ivan could engage with.

Thus learner meanings, in cases where they were different from Ivan's, were not dealt with. All learner activity involved responding to the teacher in whole class interactions and the entire lesson was in English. While this study does not focus on language issues in the mathematics classroom, or on patterns such as chanting (for this refer to Setati & Adler, 2000) the fact that the entire lesson was in English did restrict Ivan's ability to work with learner understandings, since many learners had a very weak English language base.

In contrast, by the second and third observed lessons (seven and thirteen months later), as shall be explored below, the absences noted above, such as an absence of questions requiring mathematical explanation, 'became present'. There was movement from teacher-centred practices towards more learner-centred practices[3] and there was more engagement with mathematical concepts and learner meanings.

This changing practice reflects Ivan's changing understanding (meaning) of new curriculum ideas, Ivan's changing roles and identity as a teacher (becoming more of a learning mediator), Ivan's changing relations with learners in his classroom community and Ivan's increasing confidence in each of the above.

Ivan's second lesson observation - 7th October 1999

The mathematical content of the lesson included using fractions, percentages and decimals to solve various problems involving buying clothing, budgeting in a household and comparing test performances. Ivan also worked with 'rounding off.' At the end of the lesson Ivan discussed other everyday contexts in which learners could apply the skills they learnt in the lesson.

Ivan began the lesson by getting learners to say what they know about percentages. He put a jersey on the board with a price tag of R200 on it and writes '75% off'. He then calculated (with learners following the calculations on the board and sometimes coming up to the board and doing the calculations) the percentage discounts and final selling prices of this and various other items. Ivan then asked learners to estimate what they could buy with R100 given the discounts on a range of clothing items.

After working out some simple percentage discounts and such as 75% of R200 Ivan got the learners to calculate 25% of R33. The calculations of this question forced learners to interpret, in context, the meaning of a remainder. That is, when a learner did the calculation at the board he got 25% of R33 = 8 remainder 1. The learners did not know what the 1 meant. Ivan pushed learners through a series of questions to figure out what this '1'meant. Once learners knew it was **'***1* quarter of *a Rand*' Ivan explained that while a quarter of a Rand is correct it does not make sense in the context

[3] Clearly there was movement towards more learner-centred practices in terms of Cuban's (1993) list of criteria for teacher-centred versus learner-centred practices. However movement did not emerge on two of Cuban's criteria that is, on varied instructional materials (in both lessons Ivan draws on the world around him and uses the text book for ideas) and there is no noted change in learners determining the rules of behavior in the lessons.

of money. He pushed learners to then convert ¼ of R1 to a decimal. One learner suggested that ¼ = 0,4. Ivan dealt with this misconception by getting the learner to do the division of 1 by 4 to see that this is not the case. In the above, Ivan explores some of the links between fractions, percentages and decimals, that is that 25% of R33 = R 8 ¼ = R8.25.

Ivan went on to put a table of a fictitious family's monthly budget on the board. He asked learners a range of straightforward questions to be answered from the table. For example he asks learners if R2000 is sufficient to cover the budget (this requires addition of the amounts in the table, see lines 2-9 below) and he asks how much money is spent on the different items on the budget (this simply involves learners reading this information from the table, see lines 9-14). From this he continued with the main focus of his lesson, working with percentages. He got learners to derive the fraction that each item on the budget represented and to convert these fractions to percentages (lines 15-21 below). Ivan did not show the learners how to do this but rather got a learner to come up to the board to do it. He guided the learner with questions and tips at the board, and encouraged the learner to explain to the class what he was doing (lines 17-20).

Extract from lesson:

Ivan wrote on the board

Food	Rent	Electricity	Phone	Transport	Various	Savings
R800	R700	R150	R50	R90	R100	R100

1. Ivan: Right this is a budget for a family. Okay. This is a budget for a ?
Class choruses: family.
2. Ivan: At home you know they must pay the rent for the house right? They must also pay the electricity right? And they must also pay for the phone and transport to school and transport for parents to go to work neh? And for other things and every month your mother puts away R100 every month…inaudible.
Let's say your father and your mother both of them they bring home R2000 Neh? When they are combined neh? …To all those things out of that R2000 do you think that is enough heh? Heh?
Class: Yes
3. Ivan: Heh?
Class: Yes
4. Ivan: Why do you say yes? Why do you say no? Who said yes? All of them combined must be R2000… (inaudible). Why do you say yes because?
Learner: Because phone and transport
5. Ivan: Phone and transport what about them?

Learner: inaudible explanation

6. Ivan: Now listen to you? Now he says it is a little because it won't cover all the expenses heh? Why, I want to know why? I want you to tell me. They must spend R800 on food. They must spend R700 for rent for electricity R150 for the phone R50, for the transport R90 for various things R100 and they must save R100 every month. But now the money that they bring home is only R2000 is that money enough

Class: Yes (some learners answer no)

7. Ivan: Who said yes?

Learner: If you add those there that you have they will be less than R2000.

8. Ivan: When you combine all their expenses neh? What?

Learner: they make about R2000

9. Ivan: R2000 is their budget. Sipho says that money if they do that every month the money is enough. What part of the budget is spent on food? How much do they spend on food?

Learners: R800

10. Ivan: R800 neh? And then on rent how much do they spend? Don't sing.

Learners: R700

11. Ivan: And on electricity?

Learners: R150

12. Ivan: Transport?

Learners: R90

13. Ivan: Various?

Learners: R100

14. Ivan: savings?

Learners: R100

15. Ivan: Now the question is what fraction is spent on food? What fraction is spent on food? How much is the income? How much do they bring home?

Class: R2000

16. Ivan: R2000, now what fraction of their income does food take? Now you are going to say (pause) what is this fraction of? (Pause) their income? (Pause) Yes talk!

Learner: 800 over 2000

17. Ivan: Yes very good its going to be R800 over 2000. Now I want you to come and work out the percentage. Who wants to come and work out the percentage. 800 over 2000 what percentage is that come on its what we've been doing, who wants to come and work out that? Come, come, come!

Learner comes to the board

18. Ivan: work out the percentage

Learner pauses at board for a tip

19. Ivan: for percentages must multiply by 100 over 1

Learner writes: 800/2000 x 100/1

20. Ivan: Work it out. Right tell us what you are doing.

Learner: inaudible (learner solves the problem at the board and explains her cancelling)

Ivan went on to give various learners a chance to work out the percentages each budget item made up at the board and encouraged them to explain how they got their answers. He encouraged the rest of the learners to try the problems for themselves while learners were busy at the board and he moved around giving individual attention to learners. When a learner made an error at the board, or on the paper they were working on, he challenged them with questions and sometimes provided tips without giving the solution. For example:

21. Ivan: But there is a remainder boy. What about the remainder, did you throw it away? Nothing should be thrown away right?
(While Ivan was saying this, another learner got up to help the learner at the board. She explained to the learner at the board what to do with the remainder.)

22. Ivan: Right is it correct now, heh?
Class: Yes

Once each of the percentage for each of the budget items was done Ivan asked:

23. Ivan: How much do they save in a year?
Learner: Say 100 x 12
24. Ivan: Why do you multiply by 12, why not by 13?
25: Learner: There are 12 months in the year.

Ivan then moved on to comparing fractions through converting to percentages and did this in the context of comparing fictitious marks learners achieved on tests (for example Meshak got 15/40). He asked learners to suggest other possible marks (for example Steve got 41/80). He wrote these marks on the board and asked:

25. Ivan: Who got higher marks?
Class: Meshak, Steve
26. Ivan: Some say Meshak others say Steve. Somebody go and work out the percentage for Meshaks marks?
(A learner went to the board and wrote: 15/40)
27. Ivan: What is the percentage of his marks?
Learner: 70% (learner writes 70% on the board)
28. Ivan: She says 70%. How did you get that? Show us.
(Learner does work on the board and gets stuck)

29. Ivan: She added, why tell me. You want to know the percentage. You want to know out of 100, how much is that. So you are going to? Somebody help her. She added the numerator and the denominator she added 15 and 40 and got 55, is that right?
Class: No
(Another learner comes to the board and explains that 15 + 40 = 55% thus he also added the numerator and the denominator)
30. Ivan: He has also added the numerator and the denominator. Is that right? You can't think straight what is wrong? Why don't you show me your steps, ne, why don't you show me?... (inaudible)

Ivan then moved to the board and guided the learner individually at the board (inaudible) and thereafter he moved around the class helping learners individually while the learner continued at the board.

Commentary on the mathematical content of the lesson:

The lesson dealt with converting between fractions, decimals and percentages and Ivan showed an attempt to integrate these with real life contexts familiar to the learners. The lesson engaged with these three concepts in a way that connected them to each other and to real life problem solving. Ivan maintained his mathematical focus of calculating percentages of amounts and converting from fractions to percentages. The mathematical goals of the lesson were much clearer than for the first observed lesson.

However, Ivan did not link the percentages for each item in the table to the whole 100%. In other words, he did not push learners to check that their percentages in fact made up 100% of the budget and indeed there was no mention of the need for the percentages to add up to 100. There was thus an absence of engaging learners in understanding the connection between the fraction parts and the whole. A possible reason for this is that since all the work is done on the board (and erased once each item was complete), there was no complete record of each percentage which would be necessary to make this connection. If learners had been doing the work systematically in their books or on a worksheet the notion that all the percentages should add up to 100 would have been easy to check.

An interesting interaction happened in the lesson in relation to Ivan's linking mathematics with the everyday world. In this lesson the mathematics of fractions and percentages was linked to a household budget. In line 2 of the extract Ivan asked learners if the budget was enough (meaning if

R2000 was enough for all the listed budget items). It seems plausible that the learner who responded with 'no' to this question, might have interpreted the question to ask whether the budget made sense in the everyday world (see lines 2-6 above). In line 4 the learner answers no and explains 'because phone and transport'. Unfortunately the tape was inaudible at this point but it seems likely that the learner did not think that R50 for phone and R90 for transport was enough money for those items. Indeed in the real life context R50 would barely cover the basic monthly rental cost of a telephone. The learner was not given the time or the opportunity to clarify what he was saying.

This incident points to some well documented difficulties that arise when one brings the 'real world' into the mathematics classroom and learners are left to figure out what the recognition and realisation rules are in the mathematical classroom (discussed in Part 1 of Chapter 2).

Commentary on the style of the lesson:

While one would not necessarily describe the above lesson as typically 'learner-centred' there was a clear move from Ivan's first observed lesson towards *more* learner-centred practices. In the above extracts we see that Ivan allowed learners to do mathematics calculations for themselves rather than merely watching, following and responding to Ivan's demonstration. He encouraged learners to do the problems themselves and not just to watch those at the board doing them. Many learners were actively involved in doing calculations themselves (either at the board or, for a few learners, at their desk), although many learners were still passively watching without working at their desks.

Ivan took more of a guiding role with learners rather than showing and telling all. He tended to try to get learners to explain their meanings and made an effort to engage with these meanings. Ivan regularly asked learners why they gave the answer they did and encouraged learners to show their methods (at the board) and to explain their thinking (lines 4-6, 20, 24, 29-30). Eliciting learner explanations seemed to be part of everyday classroom practice since learners at the board were quite comfortable in explaining what they were doing.

Other changed practices, included in this lesson, that indicated *movement* toward more learner-centred teaching were: more learner talk, some individual interaction between Ivan and learners (i.e. not all interactions were whole-class interactions as in the first observed lesson), and there was

some input from learners into the content of the lesson (learners volunteered test marks to work with). Ivan also occasionally switched between languages to help explain a concept to a learner.

Despite these shifts, for the many learners, activity was restricted to responding to questions in whole class interactions and to watching other learners solve problems at the board. In other words, only some learners followed Ivan's encouragement to work on the problems themselves at their desks. The absence of learner activity in terms of doing *written mathematics in their books* seemed to be typical of other lessons, evidenced by the fact that little written mathematics was found in learner books and by learners not taking out their books at the start of the lesson. Learners also did not have textbooks, which meant that giving homework was problematic.

Ivan's third observed lesson on the 12th May 2000 shows a similar movement towards more learner-centred practices (i.e. less teacher talk, more working with learner meanings and more working with learners individually) but the main shift from the second observation is the substantial increase in individual learner activity. This was evidenced by the fact that a large portion of the third lesson involved *all* learners doing written mathematics in their books. The lesson began with all learners taking out both their mathematics workbooks and their textbooks. It seemed clear that this was standard practice at the start of a lesson. I discuss this lesson briefly below:

Ivan's third lesson observation – 12th May 2000

The lesson focused on the division of fractions. Ivan began by putting up the following fraction chart on the board:

1							
½				½			
1/3			1/3			1/3	
¼		¼		¼		¼	
1/5		1/5		1/5		1/5	
1/6		1/6		1/6		1/6	
1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8

Ivan asked the class a range of questions that learners answered with reference to the chart. For example: How many quarters are there in ½? He then moved on to solving these same division problems by using the method of inverting and multiplying by the divisor and would verify the solutions by referring back to the chart.

Extract from the lesson:

1. Ivan: Lets look at other examples as well. Lets say how many eighths will give me ½? How many eighths will give me ½? How many eighths will give me ½? Isaac?
Learner: (looking at the chart) 4
2. Ivan: He says there are 4 so lets see how do we arrive at the answer using the same principle ne right lets see. (Ivan writes: ½ ÷ 1/8 = ½ x 8/1)
We say how many eighths will give me ½ ? Two, into eight, how many times?
Class: 4
3. Ivan: and we start with the smaller number first, two into 8 goes? (On the board Ivan is doing the cancellation of ½ x 8/1)
Class: 4
4. Ivan: And then? What do we do? (Ivan has on the board now ½ x 4/1)
Learner: 1 by 4
5. Ivan: 1 by 4 is ?
Class: 4
A few learners: 1 times 1 is 1
6. Ivan: final answer is?
Class: 4
7. Ivan: (Ivan writes = 4) Do you see?
Class: Yes
8. Ivan: Let me give you more examples and then class-work. (Ivan opens one of the two textbooks on his desk and refers to it for more problems). Right lets do this one (pointing to the chart). How many sixteenths in a half?

Ivan solved this problem in the same style as above (i.e. first from the chart and then using the 'invert and multiply' method. Thereafter he moved onto solving division problems with mixed numbers such as 1 ½ ÷ ¼ and 2 ¼ ÷ 1 1/8. After they completed the problem 2 ¼ ÷ 1 1/8 (by the 'invert and multiply' method) and concluded that the answer was 2 Ivan challenged the class to prove that the answer of 2 was correct.

9. Ivan: So 2 ¼ ÷ 1 1/8 the answer will be ?
Class: two

10. Ivan: Can you prove that it's true. Can I say that one and one eighth plus one and one eighth, can somebody come and prove that the answer will be two? We are having two 1 1/8's in 2 ¼ right. We get two of these out of one of these (pointing to the 1 1/8 in the sum on the board). We get two of these. Can somebody come work this one out?
(Learner comes to the board and writes 1 1/8 + 1 1/8)

Ivan emphasized that they were now working with addition and asked the learners how they work with this.
The learner completed the addition calculation at the board. Ivan concluded that since 1 1/8 + 1 1/8 = 2 ¼ it was therefore true that 2 ¼ ÷ 1 1/8 = 2.
Ivan then went on to do another example with learners at the board: 12 ÷ 2/3. Thereafter he moved onto 'class-work'.

11. Ivan: Right page 123 I want you to do a,b,c,d and then go to j and k right a,b,c,d, j and k. Right start now I want to move around and see what you do.

At this point all the learners began to work on the problems in their workbooks from their textbooks. Every learner had a textbook. Ivan spent the rest of the lesson moving around, looking at what learners were doing, helping learners individually or in pairs and groups where he found they had a problem or where they had made a mistake. Rather than tell the learners what to do he guided learners to find their mistakes, for example[4] in an interaction with one learner who made an error in multiplying fractions:

12. Ivan: How did you multiply here, how did you get that?
Learner: response inaudible
13. Ivan: yes and then?
The learner continued to explain her method and it became clear that what she had written was different from what she had explained.
14. Ivan: yes and what did you write?
The learner then went on to fix the error.

This individual (and in some cases learners worked in pairs) 'class-work' took approximately 40% of the lesson time. All the learners were busy working at the problems throughout this time until the lesson came to an end. Learners were requested to complete the problems for homework.

[4] It was extremely difficult to pick up learner voices in these individual interactions due to the position of the camera being at the back of the class. The camera did however pick up Ivan's voice more clearly and this excerpt indicates the mediation style of Ivan in trying to get learners to find their own errors.

Commentary on the mathematical content of the lesson:

The mathematical focus was on the division of fractions and reconciling learnt methods with visual (from the chart) methods. The lesson progressed from division of simple well-known fractions that were easily solved and verified with reference to the chart (see lines 1-8) to more complicated fractions that involved mixed numbers which could not be easily done using the chart (see line 9). To verify such answers Ivan resorted to another method (checking by addition) see lines 9-10. Learners were given time to consolidate and practice the skills of dividing fractions (see line 11).

In the lesson Ivan challenges learners to see the connection between division of fractions and addition of fractions. He challenges learners to prove that 2 ¼ ÷ 1 1/8 = 2. Although Ivan quickly provides the method of checking whether two '1 1/8' will make 2 ¼ i.e. by getting a learner to solve 1 1/8 + 1 1/8 on the board, this question did highlight Ivan's intention to get learners to understand the interconnectedness between operations.

Commentary on the style of the lesson:

The primary change in the style of this lesson is the inclusion of class-work and homework, and a major increase in the time Ivan spent working individually with learners (about 40% of the lesson). Class-work and working from textbooks was clearly part of a typical lesson as evidenced by learners taking out both class-work books and textbooks at the start of the lesson. In both previous observed lessons many learners had nothing on their desks and where learners had books on their desks they were often closed. Ivan's style of working with learners individually involved asking learners questions to help them find their errors and to give Ivan insight into their misconception (lines 12-14). The desks were arranged in groups of 6-8 so as to facilitate group work and learners working together (in the previous lessons individual desks were paired in rows of two).

It is important that Ivan's movement towards more learner-centred practices be interpreted contextually against the background of dominant teaching practices within 'township' schools such as the ones Ivan taught in. Ivan's trajectory in terms of changing practices was clearly shaped and framed by the changing context within which he was working. That is at the start of 1999 textbooks relating to Curriculum 2005 were not available at Ivan's school, and textbooks relating to the previous curriculum were scarce.

In this respect Ivan's use of two textbooks in order to prepare the lesson and his use of textbooks with learners is a central factor in Ivan's increased confidence, improved clarity of direction in the lesson, maintaining a mathematical focus and the increase in individual learner activity. Thus, while for Cuban (1993) heavy reliance on a textbook is usually interpreted as an indicator of teacher-centred practices, in this case the use of textbooks to plan the lesson and to provide individual learner work resulted in a lesson in which the mathematical focus and direction of the lesson was clear, and learners spent much of the lesson *themselves doing* mathematics (allowing Ivan to evaluate and mediate learners individually). The absence of textbooks in the first two observed lessons seemed to result in less logically structured lessons, evidence of a range of misconceptions in relation to the mathematical content of lessons, an over reliance on teacher talk, and limited written work on the part of learners.

While it is often problematic to draw conclusions as to a teacher's shift towards more learner-centred practices and deeper engagement with mathematical meaning from a limited number of lesson observations, the data concurs with Ivan's own explanation of how he perceived his classroom practices and his confidence in teaching to have changed over the period.

Part 3: Increasing status and participation in a range of activities

In a reflection session on Ivan's second observed lesson of the 7th October 1999 [Reflection field-notes], Ivan explained that his participation in and with the PLESME community had changed the way he was perceived in his community and provided him with a level of 'expert' status. He explained how this contributed to his being offered the Head of Department position at his current school and that a group of publishers approached him to become involved in working on a primary school mathematics text book.

Furthermore, Ivan explained that the previous year he was thinking of leaving teaching but that he was now 're-motivated'. In the final interview, Ivan noted that he might be interested in studying further: 'you yourself appreciate the subject and dig deeper or do further studies' [Ivan Interview, November 2000]. The emergence of a stronger identification with mathematics teaching as a long-term career (as evidenced by Ivan's choice to stay in the profession and to possibly study further in mathematics education) is important in relation to the rationale of PLESME. As explained in

Chapter 3, Part 2, most teachers of mathematics in South Africa are not qualified mathematics teachers. Ivan's choice to stay in the profession and to study mathematics beyond PLESME indicates his development of a stronger identity as a mathematics teacher.

In the reflection of the third lesson Ivan requested that all the mathematics teachers at his school watch and comment on his video with him. This indicates Ivan's increasing confidence in his teaching practice and in his willingness to share ideas with colleagues.

In the questionnaire at the end of 1999 Ivan explained that he had become involved in a wide range of new activities. For example, he had been to the Lenasia Teacher Centre (that he first visited during a PLESME fieldtrip) to find appropriate textbooks and learner materials for his school. He had shown these books to his colleagues and had recommended that they also attend the teacher centre in search of ideas and resources. He explained 'the staff at our school was impressed about the idea'.

By July 2000 Ivan's participation (and status/identity) with others in his community had continued to increase. He explained in his questionnaire how his relationship to other mathematics teachers had changed: 'The colleagues have more confidence in me because I share with them the new information they refer other children…Teachers from other schools invite me to ask for solutions' [Ivan Questionnaire, July 2000]. Ivan continued in the questionnaire to say that he held regular meetings at his school and that he shared information with teachers. He explained the nature of this sharing involved discussions on how to ask effective questions and how to contextualise mathematics. He added that he was helping his school to launch a computer centre and had approached the Lenasia Teacher Centre to provide software.

The examples above illustrate close links between Ivan's changing practices, his increasing alignment and engagement with the PLESME community and his school community, his changing identity (by others and his identification of himself as someone who wants to remain a mathematics teacher) and his increasing confidence.

Part 4: Alignment to a range of communities

The examples of Ivan's changing practices above illustrate a changing alignment on the part of Ivan to various communities related to his being a mathematics teacher. We have already seen illustrations of Ivan's changing relations with his learners (i.e. his classroom community), his changing status with parents, his principal (who offered him the 'Head of Department' job) and with fellow teachers both in his school and neighbouring schools (his school community).

In addition, there is an increase in Ivan's alignment and engagement with the PLESME community and to professional associations such as AMESA. I expand on this briefly.

With time Ivan's perception of the role of presenters and other teachers in the PLESME community changed. When asked in June 1999 how he saw the role of presenters he explained them as 'inspiring'.

I think they're (presenters) inspiring, their love for the subject I think it rubs off, in terms of how they present the subject, their confidence, one wants to emulate that, and the new ideas that they bring and also from different experiences that you have drawn from other teachers, your colleagues like us, so its sort of an eye-opener to realise that oh some people approach this thing this way how do I relate to that, how would I have approached it, or maybe it's a similar experience to mine only to find that I had approached it differently, but if I had done it that way I would have coped better. Like that example you gave of that child, huh? They were given money to divide it
MG: Yes Oh Karabo[5]
Ivan: Yah yah Karabo yah yah. It was eye opening, Karabo's experience. In that particular instance going from other's experiences, it was quite inspiring [Ivan Interview, June 1999].

In explaining his view on the role of other PLESME teachers in assisting Ivan's learning Ivan described this as 'nice':

[5] The reification of 'Karabo', as evidence of the importance of listening to learner explanations, occurred after a PLESME workshop in which a video of a class of children was shown to teachers. In this video a child, called Karabo, came up with a very unusual method to divide up money. After the PLESME teachers watched the video they were given the workings of various children to mark. All the PLESME teachers agreed that Karabo did not understand the problem and all his work should be marked wrong. The facilitator then continued the video and showed how the teacher asked Karabo to explain his method and how after listening to the explanation it was clear that Karabo's method of solving the problem was quite sophisticated. Throughout the data teachers referred to 'like Karabo' to highlight the importance of working with learner meanings.

Okay in terms of sharing of ideas you know, like that guy (Karl) going from different experiences because normally we don't talk about different experiences you know we discuss how they are coping, the different language groups how do they make sense of information like Thandiwe (a presenter) was talking about mother-tongue. So bringing in teachers from different schools, *it's nice*. . [Ivan Interview, June 1999].

By November 1999 Ivan noted sharing ideas with teachers from other schools as the first major benefit of participating in PLESME. That is, he saw this as an important part of the PLESME practice and no longer saw this aspect as simply 'nice'. Ivan wrote in response to the major benefits of participating in PLESME:

The PLESME programme is very eye opening in the sense that teachers of various schools and backgrounds are involved this helps because we share different ideas. The programme coordinators are very dedicated and they are also drawn from different fields of approach [Ivan Questionnaire, November 1999].

Furthermore, Ivan explained his working with teachers from Eldorado Park as an *exciting experience* and that the sharing of common problems and relating to them had brought the teachers closer together [Ivan Interview, August 2000]. He also explained how he was confident enough to ask a PLESME colleague to run a workshop with his learners on fun creative mathematics ideas, thus indicating his willingness to draw on the PLESME community for support [Ivan Interview, November 2000].

Ivan's alignment to various communities also included the professional association of AMESA. He described his experience of his participation in the AMESA (a professional mathematics education association) conference where he presented a paper as follows:

A very educational experience, learning different methods and exciting ideas from different educators from different places even from overseas. Meeting people who were so willing to share their ideas and exchanging telephones it was so fulfilling [Ivan Questionnaire, July 2000].

An important point in relation to Ivan's changing alignment to various communities is the way in which Ivan extended his 'professional community' from being constituted by his learners and colleagues at his school to being constituted in addition by teachers from schools in other districts (most notably Eldorado Park teachers in PLESME), teacher educators from a range of

organisations, educators in local district offices and teacher centres, and teachers and educators in the professional association of AMESA.

Ivan's response to the major benefits of participating in PLESME in the November 1999 questionnaire (see quote above) highlights the extent to which Ivan valued working with teachers from different backgrounds and presenters drawn from different fields. It is important to note the enormity of this extension in relation to the way in which the Departments of Education were highly segregated under apartheid and to note the significance of such an extension in this post apartheid era. Teachers in the then African Department of Education and Training were cut off from teachers in other Departments (see Chapter 1) and were not permitted into national mathematics associations such as the Mathematics Association of South Africa as this was reserved for white teachers only.

Part 5: The emergence of confidence

In each of the Parts 1 to 4 above, confidence emerged as either a result and/or an explanation of Ivan's learning. Later, in an interview (November 2000) Ivan himself explained the way in which his increased confidence related to his changing understanding, practices, identity and participation in communities. In this interview teachers were asked to explain what they had meant by 'confidence' when they used it in response to questions in earlier interviews and questionnaires. Ivan responded as follows:

1. Ivan: By confidence I mean the command of subject. Okay the strategies in presenting the subject, the approach,
2. MG: And what does it mean to be more confident at these?
3. Ivan: I'm in a better position to can bring a child to appreciation of the subject, mastering the subject, understanding the learning programmes. Okay? And broadening the child's understanding of the subject…(inaudible)
4. You know personally when you are confident about the subject it is easier to impart it than when you are not sure…
5. Even the children can pick it up (tape runs out; rest from notes)
6. You yourself appreciate the subject and dig deeper or do further studies.
7. Like I have given you the example that teachers are afraid (of new Curriculum) because they have never done it. So it means you rise to the occasion.
8. Others have more confidence in me, they (teachers in his school and other schools) are asking me to set papers and evaluate theirs, so it means they have confidence in me.
9. Also interacting with other teachers, how Mr. Modise (his principal) came to support me and wanted me for his school, its how it comes about and interacting with other teachers, like knowing guys like Cedric, Karl.

10. Like for instance I was confident enough to invite Barry (a teacher in PLESME) to do this part of a lesson and the kids will enjoy it. I have confidence in myself for inviting him.
11. We are usually afraid to do this because it means admitting weakness. Confidence allows me not to have to know everything [Ivan Interview, November 2000].

Lines 1 and 3 of the extract above illustrate a link between confidence and practice. In this respect practice involves access to knowledge (and meaning) and an ability to use this knowledge to help learners understand mathematics. In other words confidence enables him to teach successfully.

Lines 4, 5, 6 and 7 illustrate a close link between confidence and identity. An identity as a teacher who can teach with ease (line 4), who is not afraid to take on new challenges and who believes in his ability to rise to those challenges (line 7), who has an interest in the subject of mathematics (line 6) and whose learners identify him as being more able (line 5).

Lines 8, 9 and 10 illustrate the interconnectedness of confidence and community. The community provides the support that encourages confidence (lines 8-9) and the community stimulates a change in practice in that Ivan has to take up new roles and practices in relation to that community (e.g. evaluating their papers). And this relates to a changing identity in that community as someone who has 'expertise' in these roles and practices. Similarly line 10 illustrates the interrelatedness between confidence, community (support) and practice. Here Ivan draws on a fellow teacher to do a lesson for his class, a practice he has never used before.

Line 11 captures Ivan's final and summary thoughts on confidence. Confidence allows him not to have to know everything. It indicates a change in his identity towards someone who confidently views himself as a life long learner with the ability to access resources for learning in changing situations. This resultant confidence, in a self-fulfilling cycle, results in further confidence. Ivan has developed confidence and therefore he knows he does not have to know everything *and* Ivan knows that he doesn't have to know everything in order to be competent. He therefore develops more confidence. Thus, confidence is both a product of Ivan's learning and a process of his learning.

The above vignette clearly establishes that learning did occur for Ivan since there are identifiable changes in Ivan's 'being' as a mathematics teacher. These changes in Ivan's being and *identity* as a mathematics teacher extend to his classroom, his ability to experience changes in the new curriculum as *meaningful*, his *activities* in the broader profession of mathematics education, his

professional *communities* and in his perception of himself. This is evident both from what Ivan said in interviews and questionnaires, and from what Ivan did as recorded in classroom observations and field notes.

The vignette illustrates that Ivan's learning to become a confident mathematics teacher was about his changing 'becoming', and immersion in particular practices (associated with particular meanings) that were valued by South African society at a macro level (new curriculum policies) and the various professional communities (including the PLESME community, school communities and the AMESA community) at the micro level.

In summary, the vignette above illustrates that Ivan's learning centrally involved increasing confidence in relation to: his experience of mathematics teaching (and the new curriculum) as meaningful; his experience and practice in the profession of mathematics teaching; his changing status and increased identification with the profession of mathematics teaching, and his participation and alignment to various communities.

Therefore, I argue, Ivan's learning in relation to increasing confidence involved mastery of the practice of being and of becoming a professional mathematics teacher. Ivan both achieved a further[6] level of mastery in the profession of mathematics teaching, in relation to what he learnt, and he embarked on a process of ongoing development of mastery that involved the confidence to admit that there was still much to learn and an identification of himself as a life-long learner within the profession of mathematics teaching.

The vignette provides a textured story from which a 'frame' emerged that is used for analysis of teacher learning in relation to the broader sample of PLESME teachers that follows in Chapter 7. This frame is used to identify the mechanisms that enabled mathematics teacher learning and to explore and elaborate on the nature of teachers' learning in relation to their becoming confident mathematics teachers (in a context of curriculum change in a post apartheid South Africa).

[6] I use the term 'further' to emphasise that all teachers began their learning process during PLESME as practicing mathematics teachers. They were therefore considered as professional mathematics teachers with different levels of mastery in relation to different aspects of the profession.

The frame for analysis of all teachers' learning

As explained in Chapter 4, the choice to use Wenger's four components of learning in the analysis emerged from a dialectical process of moving between becoming immersed in social practice theory and becoming immersed in the data. Wenger's (1998) four components of learning became available to me in March 2000 and therefore were not used in the design of the research. In the process of the data analysis Wenger's theory of learning has in a sense been 'read onto' the data *and* has emerged from the data. The emergence of 'confidence' as a central phenomenon of teacher descriptions and explanations of learning, and as a fifth component of learning, is however completely grounded in the data.

These phenomena are evident in the vignette of Ivan, and the vignette further illustrates that the mechanism that enables teacher learning *is* about access to participation in and resources relating to Wenger's four components of learning: *meaning, practice, identity and community* with the addition of access to resources that enable the development of *confidence*.

Part 1 of the vignette illustrates primarily Ivan's changing understanding and ability to make *meaning* of curriculum change, learner-centred philosophies and new mathematical outcomes. It also shows Ivan's increasing confidence in engaging with others about his understanding of the new curriculum. Part 2 of the vignette illustrates how Ivan's changing understanding is taken up in classroom *practices* and shows increasing *confidence* in his new (and primarily more learner-centred) roles in the classroom. Part 3 shows Ivan's increasing participation in a range of professionally associated *practices* and illustrates a close connection between this, his changing *identity* (and increasing status) and *confidence*. Part 4 illustrates the relationship between Ivan's learning in relation to his alignment to a range of *communities* and his increasing confidence in participating fully in these communities. Part 5 illustrates the way in which, according to Ivan, his increasing *confidence* both describes and explains his learning. These descriptions and explanations are closely connected to Ivan's learning in relation to his changing meaning, practices, identity and participation and alignment to communities.

Thus, methodologically, analysing one teacher in-depth at the start of the data analysis validated the use of Wenger's four components of learning as a frame for structuring further analysis of learning

for all teachers in the sample. It is useful to note that what the above vignette and resultant frame hides is the too-ing and fro-ing between a more grounded analysis of the data and the merging of this analysis with Wenger's learning components as a theoretical framework for communicating the phenomena of the study. There is a tension in that *doing* data analysis and *communicating* the analysis is not the same thing. The data analysis began without reference to this frame and initial analyses were not structured in this way. After dialectically moving between the initial data analyses and the theoretical framework, a restructuring of the analyses emerged and the emergent frame has been used both to communicate the findings more clearly and to further interrogate the initial analyses.

As discussed at the start of Ivan's vignette, the story I have told is of necessity selective. The validity of the vignette in illustrating the nature of teacher learning in the PLESME community must however still be established. In order to do this Ivan's story must be located within the context of the broader sample of teachers who formed part of this story. In Chapter 7 I look at how Ivan's story is located within the broader sample of teachers, and draw on the larger sample of teachers to elaborate on the nature of teacher learning (in relation to participation in the PLESME community and to curriculum change).

Chapter 7: The nature of teacher learning: evolving meaning, practice, identity, confidence, and participation and alignment in communities

The difficulty of evidencing teacher learning, teachers' changing knowledge and teachers' changing identities are well known and have been discussed earlier. The nature of this study enables me to do so in qualitative and rich ways. This does however require somewhat lengthy descriptions and analysis.

The model of five learning components, described in Chapter 5, provides a useful frame and structure with which to explain mechanisms of teacher learning and to explore the nature of that learning (in relation to INSET and curriculum change) in more depth. In this chapter, I unpack the nature of PLESME teacher learning in relation to each of these components. For the purpose of giving the study structure and a workable frame, I deal with each component separately. It should be remembered, however, that these components are closely and complexly interconnected (as illustrated in the data analysis that follows and in the vignette of Ivan). This chapter is divided into five parts relating to the five learning components. These are:

Part 1: Teacher learning as evolving understanding and meaning.
Part 2: Teacher learning as evolving practice.
Part 3: Teacher learning as evolving mathematical identity.
Part 4: Teacher learning as evolving alignment and participation in communities.
Part 5: Teacher learning as evolving confidence.

In each part I elaborate on both the way in which each component explains a *mechanism for learning* and I explore *the nature* of that learning. I also draw out connections between the components so as to illustrate the complexity of learning to become a 'professionalised' mathematics teacher.

In Chapter 4, I argued for the importance of providing quotes and narrative vignettes so as to enable the reader to become co-interpreter of the data. Due to the inclusion of a wide range of quotes and vignettes this chapter is necessarily much longer than other chapters in this study.

In Part 1, I discuss the changing understandings and meanings of the teachers in relation to Curriculum 2005 with a particular focus on teachers' changing understanding of new mathematical areas in Curriculum 2005.

In Part 2, I discuss various new practices and forms of participation that teachers adopted over the two-year period. These new forms of participation and changing practices relate to the 'take-up' by teachers of the generic roles for educators (discussed in Chapter 1) and the mathematics teacher roles inscribed in the new curriculum (discussed in Chapter 2).

In Part 3, I draw out the relationship between the adoption of these new roles (and practices) and strengthened teacher identities as *professional mathematics educators* and focus on the aspect of the development of *mathematical* identities.

As noted earlier, this chapter focuses on the similarities and differences in teacher learning across the sample of ten teachers. It argues that one of the most visible differences between teachers (as evidenced by the data collected) related to their mathematical trajectories. That is the differences were primarily a function of teachers' mathematical knowledge, experiences and interests. These differences are discussed in detail in Parts 2 and 3 of this chapter and are elaborated with the aid of narrative vignettes.

The focus on differences in relation to the development of mathematical identities is important for this study for three main reasons. First, the focus of this study is on *mathematics* teacher learning and it is therefore important to hone in on aspects of teacher learning particular to mathematics. Secondly, the differences between teacher learning in this study emerged primarily in relation to the differences in teachers' mathematical identities. And thirdly, there is a wide range of literature that raises concern for the introduction of curriculum reform and/or more learner-centred and investigative approaches to teaching without a strong mathematical base (Chisholm *et al.,* 2000; Manoucheri & Goodman, 2000; Irwin & Britt, 1999; Jansen & Christie, 1999) and it is therefore important to explore the nature of the difficulties that arise at the intersection of new curriculum practices and mathematical competence.

In Part 4, I discuss teachers' changing alignment and participation in various education communities, namely: the PLESME community, the school community, friends and family, the local district community and professional associations.

In Part 5, I analyse the nature of teachers' changing confidence as a fifth component of learning that is both productive of, and a product of, learning. In this analysis I theorise about the centrality of the role of confidence in becoming a professional mathematics teacher.

Below is a reference table for the ten teachers who form the sample of this study. This table provides a summary of the level at which each teacher taught (i.e. primary or high school), the area in which they taught, their teaching qualification, their mathematics teaching experience and the extent to which they have studied mathematics. This information highlights different histories that affected the learning trajectories on which teachers embarked.

In Chapters 1 and 2, I have explained the way in which South Africa's apartheid history differentially affected teacher training of different race groups and provided different resources to the relative Education Departments. (For example, the resources available to the Soweto teachers were less than those available to the Eldorado Park teachers). In Chapter 3, I explained the way in which many teachers in this sample entered PLESME as *teachers of mathematics* rather than *mathematics teachers*. The information provided below is important because it provides some specific data on each teacher's background (that must be considered in addition to more general contextual factors such as the introduction of a new curriculum into a post apartheid South Africa) against which each teacher's learning must be interpreted.

Table 7.1: Reference table on the sample of teachers

Name	School	Area	Teaching qualification	Maths teaching experience	Mathematics studies
Rosina	Primary	Soweto	PTC DE	20 years	Grade 12 Commercial Maths – symbol = F
Moses	Primary	Soweto	TD	12 yrs	No grade 12 maths nor further studies in maths
Puleng	Primary	Soweto	TD BA	9 yrs	Grade 12 – HG symbol = D (Specialised in Maths and Science in diploma)
Ivan	Primary	Soweto	3 year diploma in information technology	9 yrs	Gr 12 – HG symbol = E No further studies in maths
Beatrice	Primary	Eldorado Park	PTC DE (+ 3rd year of music) HDE		No grade 12 maths nor further studies in maths
Cedric	Primary	Eldorado Park	TD HDE	13 yrs	Grade 12 – SG symbol = E (specialized in maths in HDE)
Delia	High	Eldorado Park	B Sc HDE PG	10 years	Grade 12 – SG symbol = B Maths 1 in B Sc degree
Sam	High	Eldorado Park	TD HDE	3 yrs	Grade 12 – SG symbol = E Maths in HDE symbol A [1]
Elaine	High	Eldorado Park	TD FDE	11 yrs	Gr 12 – SG symbol = C FDE in Maths
Karl	High	Eldorado Park	TD HDE	3 yrs	Gr 12 HG symbol = D Maths in HDE

Key:

Note: The number of years given are for full time studies.

PTC = Primary Teacher Certificate = (1 year); DE = Diploma in Education (1 year diploma for post PTC);

TD = Teachers Diploma [2] (3 yrs); BA = Bachelor of Arts Degree (3 years); B Sc = Bachelor of Science Degree (3 years);

HDE = Higher Diploma in Education (1 year post TD); HDE PG = Higher Diploma in Education (1 year post graduate degree diploma); FDE = Further Diploma in Education (1 year post TD) HG = Higher Grade; SG = Standard Grade

[1] The symbols for other teachers in relation to their further studies in mathematics were not available. Sam however provided a transcript of his academic record with his questionnaire, and on this transcript it showed that he achieved a distinction for his mathematics studies.

Part 1: Teacher learning as evolving understanding and meaning

Teacher learning occurred in terms of changing understandings, interpretations and meaning in relation to new curriculum ideas. This learning was largely evidenced by teachers' changing ways of talking about the new curriculum in interviews, but is also clear in teachers' changing classroom practices (discussed in Part 2 below).

The interviews (in January 1999, July 1999 and November 2000) required teachers to respond to two aspects of the new curriculum: firstly to explain their understanding of, and their attitudes towards, the purposes of the new curriculum in general; and, secondly to explain their understanding of, and their attitudes towards, the new mathematics outcomes. I deal with each of these separately. This part of the chapter is therefore divided into the following subsections:

1.1 Teachers' changing understanding and ways of talking about new curriculum purposes.
1.2 Teachers' changing interpretations of the MLMMS Specific Outcomes.

For all teachers, their changing ways of talking about the curriculum in the first and second interviews revealed increased ownership of new curriculum ideas, less use of jargon in their explanations and an increase in the number of concrete examples as to what new curriculum ideas meant for teaching.

These changing ways of talking provide evidence of teachers' learning in relation to their ability to experience aspects of the new curriculum as 'more meaningful'. This learning was achieved through participation in discussions about the new curriculum during PLESME workshops (and other forums), in the process of testing new ideas in their classroom practice and in reflecting on this experience. This participation (that involved doing, talking, thinking and feeling) interacted with the processes of describing, interpreting, decoding and recasting aspects of the new curriculum (i.e. with the process of reification of aspects of the new curriculum).

[2] The three-year teacher diploma was given different names in the different racially defined Departments of Education. Furthermore, over the years the names given to such diplomas changed. For simplicity I have called all these diplomas 'Teacher Diplomas'.

1.1 Teachers' changing understanding and ways of talking about new curriculum purposes

Between the first interviews in January 1999 and the second interviews in July 1999 it was clear that for all teachers learning had occurred in relation to interpreting and talking about the new curriculum. In the first interviews teachers struggled to use the terminology of the new curriculum in meaningful ways (as discussed in Chapter 3).

In terms of teacher attitudes toward the 'new curriculum', responses in the first interview could be categorised as positive, negative, insecure and ambivalent. The most frequent response was that of insecurity. Positive and negative responses were almost equal and many teachers expressed a mixture of these responses. For example, Delia responded:

> I am a bit worried about the outcomes based education because we have a diversity of pupils in our class… I think it is a good thing, that we are moving away from rote learning, that kind of structure, so I think it is a good thing, it is worth the effort [Delia Interview, January 1999].

As indicated in Delia's phrase 'it is worth the effort' many teachers, despite their insecurity or negativity, expressed openness to learning more about it:

> I'm quite negative. I don't know if it can work, maybe, it all depends, my attitudes can change but right now I am quite negative about it [Elaine Interview, January 1999].

> Like I said I don't know much about it, I am still waiting to be trained, I am still open minded about it but if the policy states that no child fails or something like that then I don't know [Ivan interview, January 1999].

Some of the teachers had attended a once-off workshop on the new curriculum, which was run by the provincial Gauteng Department of Education, but the workshops were not mathematics specific. Here are some of the teacher comments relating to workshops on Curriculum 2005:

> A teacher was appointed to attend courses whereby at the end of the day that teacher would give us the facts [Moses Interview, January 1999].

> We haven't had a workshop or anything… There were two or three teachers that went actually to this meeting but they came and they were very negative about it [Karl Interview, January 1999].

> Only in another subject like we had one at our school, outcomes based, and we used geography as an example, where you get all the information from the children [Sam Interview, January 1999].

In response to the question concerning the information teachers were given concerning Curriculum 2005 typical responses on the questionnaires were 'very little', 'not much information', 'nothing' [Questionnaires, January 1999]. Some teachers had heard about Curriculum 2005 from friends, colleagues and the media. On the whole, teachers were very poorly informed and had received no Curriculum 2005 documentation.

Teachers gave a range of responses when asked what they understood the new curriculum to be about. The most common response in interviews (from 6 teachers) was that it was different from the 'old' curriculum.

> The new curriculum is brilliant, whereby the approach is going to be no more like the old approach, it is a new approach as to how to teach mathematics [Moses Interview, January 1999].

Many other responses could be classified as understanding Curriculum 2005 to be learner-centred. Teachers used phrases such as 'individual attention', 'learners work at their own pace' 'it takes learner background into account' 'learners are active, they enjoy it, they are interested'. In terms of teaching methods, some teachers saw the curriculum encouraging more discussion, facilitation and group work. Furthermore mathematics would be more practical and relevant, and problem solving would be important.

> I know very little about it but we have discussed it in the staff room, that's all. I know it is supposed to be more practically orientated and you have to work on pupils, the different levels of pupils [Karl Interview, January 1999].

> The new curriculum encourages children to work together. If they work together they get a common thing. Simply working in groups, getting ideas, working together, things like this [Rosina Interview, January 1999].

By the second interview teachers no longer expressed statements of insecurity regarding the purposes of the new curriculum (although they did express some reservations as to the logistics of implementing it) and were able to provide more practical examples of what the new curriculum meant for classroom practice. For example compare Elaine's response in June 1999 (below) to her response in January 1999 (above):

> It's (her views on the new curriculum) [3] quite different to the first time (laughs). What I think is a more practical approach to see whether they can use it in day-life situations, like previously it was more based on, you know, textbook work. Now I use the newspaper to see how can I implement it in day-life situations. And I think it is a good thing, its only very time consuming, and I think we need to get used to that [Elaine Interview, June 1999].

Sam's response is illustrative of the increasingly practical ways of talking about the curriculum and increased acceptance and ownership of it. In the quote below, Sam provides a range of practical examples as to what the curriculum means in practice, and shows acceptance and ownership of the curriculum as is indicated in the final sentences below:

> What we need in our education system is to equip them with skills, which they can use in their everyday life and the workplace, they must understand what this equation is for, for example, with insurance. Move away from the text book to using other materials like web pages, newspapers, magazines, I think I am equipping them with the skills they need. Running a house

[3] The contents of brackets, in interviews, have been added by myself for clarification.

> they will do this better if they understand interest rates, if they understand the formula. Less people will be able to con them. Like car salesman they don't look at whether they can afford them but look at the commission. When you've got the formulas you can work it out yourself, you can see what you can afford and what you can't afford. Then you get to small businesses and so on, decision making, tiling the floor, general maintenance, invest money, you can use these skills… (inaudible)
>
> An extra part is the history of maths. I'm more comfortable with it now. Use maths as a tool and not as a weapon, you must be socially responsible. I'm more comfortable with this new way of teaching. I am positive it is going to work. We as teachers need to make it work [Sam Interview, June 1999].

Teacher explanations of their understanding of the new curriculum in the final interviews of November 2000 showed similar changes in the way teachers were able to talk about the new curriculum. Teachers responded with explanations about the new curriculum that were generally positive and provided concrete examples of what it meant for teaching:

> I think the purposes of it, (the new curriculum) is to equip the child to generally be self-reliant. To equip him with certain skills that will make him compatible out there in the real world in whatever he might do. So that he has the life long ability to say 'listen I can do this, and, if I don't do it I have the necessary skills to go and find or gain that knowledge.' I think that is the general idea of this new curriculum. So it's a transformation of those skills, its actually developing the child as a person rather than just developing his knowledge. As a capable person to go out there, be able to do things for himself and gain what he needs to gain. If, for example, he needs to gain knowledge he should have the necessary skills to say 'I can learn further without having the necessary knowledge. Not having the knowledge should not restrict me from becoming what I want to become, because I have the ability to obtain that [Karl Interview, November 2000].

The interviews of November 2000 further reveal teachers' increasing understanding and ownership of the curriculum in relation to their increasing confidence in their understanding. For example, as

discussed in Part 5 of this chapter, teachers began to challenge and advise district officials on how to implement the curriculum. As Elaine explained:

> Even my, what do you call it? DC (district advisor) comes to ask me nowadays what do I know and think about this whole thing… Before we started this course if someone asked me what is OBE I would just rely on what I had read in the newspaper. So I couldn't talk to someone and say what I think OBE is because there was no confidence and after this course if somebody asks me I can still have an argument, can motivate… but you see the confidence also to train the other teachers in the department because I can explain what I want from them, or what is a lesson based on OBE [Elaine Interview, November 2000].

1.2 Teachers' changing interpretations of the MLMMS Specific Outcomes

In the initial interviews (January 1999), when asked what teachers understood by the new MLMMS Specific Outcomes (see Chapter 2), most teachers were unable to find meanings for Specific Outcomes 4 and 8. These outcomes included terms such as *social, political, economic, natural forms,* and *cultural products.* The teachers were unable to connect such ideas to mathematics. While specific outcomes 4 and 8 resonated with teachers' political ideologies the mathematical content of these outcomes was opaque. A common response to these outcomes was 'nothing comes to mind' or alternatively teachers simply reordered the jargon of the outcome. This is evident in Ivan's vignette in Chapter 5 and similarly illustrated by Sam's response:

> With number four, critically analyse how maths relationships are used (pause) that would be important for one of the outcomes, for instance specifics will come in here, where you can analyse specifics in certain diagrams and so on, especially say if you look in a newspaper where you see a stock and all that, that will help him a lot. Especially voters' rolls, when you see only 50% of eligible voters registered and so on. As regards cultural products and so on you need mathematical things, shape, space and time… Space and time? Nothing comes to mind. It is too broad [Sam Interview, January 1999].

While teachers' initial responses to the new curriculum were uneven and diverse, it was common for teachers to struggle to move beyond the rhetoric of the outcomes and to provide mathematical meaning for them. By the second interview (five months later) teachers were more able and willing to engage with what the new curriculum was about and teacher responses to the outcomes could be categorized in terms of increased ownership (as evidenced by increased discussion through the use of personal examples teachers had encountered or used in teaching), increased confidence (as evidenced by the absence of statements of insecurity and a willingness to engage for a lengthy period of time on the meaning of each outcome), and increased concretisation and mathematisation of the new curriculum purposes and outcomes (as evidenced by the wide range of practical mathematical examples teachers gave to exemplify the meaning of the outcomes).

While the way in which teachers spoke about the curriculum was different and the examples they gave from their experiences were different. Sam's response to how he understood Specific Outcome 4 illustrates the general shift in teachers' ways of talking about the outcomes:

> What does it mean by saying a party must get two-thirds majority[4]. Many people said you must get 67% but that is not two-thirds. Also you can't have half a seat in parliament. So that is how mathematics is important. … We must see the maths relations in this because that makes a difference. The economy, 0.2% growth, what does that mean? Why did the bond rate move down, because people have more money to spend, so jobs are created. Use maths relations directly related to our society. And look at our exchange rates, what we pay for a Sony Play Station is three hundred Rand, it's much cheaper overseas…[Sam Interview, June 1999].

Final interviews in November 2000 similarly showed increased engagement by teachers with the new curriculum purposes and outcomes and revealed a larger repertoire of examples and experiences that teachers used to explain the outcomes. This larger repertoire was linked to teachers' increased access to resources and ideas found in workshops, textbooks, Illustrative Learning Programmes etc. This is evident in Sam's explanation of Specific Outcome 4 in the final interview:

[4] At the time of the elections the press speculated widely on whether the ANC would receive two-thirds of the votes, which would allow it to change the constitution. The question that arose was where did 2/3 get rounded off (i.e. to 66,66667? or 66,7? or 67?)

Okay, this is one (referring to SO4) I use quite a lot. It's where for example in our NUE (National Union of Educators) book, one of the teachers came to me and said 'Listen they paid me wrong' and she had to be paid a bonus from the first January 2000. They paid her from the first of July 2000 and so she asked me now how much money. I said 'okay this is the formula from the National Union of Educators book so lets see how much she has been paid' and we went through that and did the substitution and all the things we do in maths, you can see the relation and we sent a letter through and they will pay her the money and the same with our increases. They came to me and asked me how so so and so. I said 'okay fine you will get this increase and calculate it' and so when I get my payslip and I work out my money the taxes everything is fine so I have the skill and the knowledge that they paid me correct… Cricket as well if you look at your cricket scores, and Lance, when he batted and the averages and so on um and that pushes up his ratings as a cricketer. And the new thing now, one of the bleaches comes out in the 1 litre and Parmelat milk comes out in 1.25 litres and the other come out in 1 litre. Your bleach is normally 750 millilitres…

MG: Okay so you think about that when you are buying the stuff?

Sam: Ya

MG: Okay, in your teaching what does this outcome mean for your learners?

Sam: Like the cell phone project we went through it and they've seen what happened when you collect your data in order to make an informed judgment for which type of cell phone offer and some of them came up with nice ideas…

With my surface area and volume when they wrapped their presents they could see the relationship... One example I use, if my class was a storeroom for the boxes how will they fit etcetera…And another we used the straight-line graph with the grade nines, see it as a tool you can use when computers down. Even some of the taxi drivers I have seen them use a graph pasted on the dashboard.

MG: Really have you seen that?

Sam: Yes maybe he was just a maths taxi driver… [Sam Interview, November 2000].

The increased repertoire of examples and the personalization of curriculum purposes and outcomes also indicate changing confidence of teachers with respect to talking about the curriculum. Furthermore, for some teachers the changing understanding of new curriculum ideas indicated the

development of strengthened mathematical identities. This is evident in Sam's interview where he explained how he helped other teachers to work out the mathematics of their salary slips, how he noted mathematical changes in supermarket products' packages and in sport scorings. Sam had become a critical mathematics interpreter of the world around him. This and other 'mathematical becomings' for Sam are discussed in more detail in Part 3 in relation to Sam's evolving mathematical identity.

In summary:

Teachers increased access to knowledge about the new curriculum and access to processes of participation (doing, talking, thinking, feeling) and reification (describing, perceiving, interpreting, decoding and recasting) in discussions of the new curriculum and in adopting new teaching practices led to a changing experience of the new curriculum as more 'meaningful'.

Part 2: Teacher learning as evolving practice

In this section, I analyse teacher learning in relation to their changing practice, where practice is taken to be what the teachers did in order to do their job as professional mathematics teachers. I analyse teacher learning in relation to two primary aspects of teachers' changing practices. First (in 2.1) I analyse changes in the practice of mathematics teaching in classrooms, and secondly (in 2.2) I analyse changing practices in relation to mathematics education more broadly (such as participation in discussions, committees, conferences, etc). This part is divided into the following subsections:

2.1: Changing Practices in relation to Mathematics Teaching

2.1.1 What teachers said about their changing mathematics teaching practices.
2.1.2 Observed changes in mathematics teaching practices.
2.1.3 The relationship between mathematical trajectories and new forms of teaching practice.
2.1.4 Changing Roles in relation to changing mathematics teaching practices.

2.2: Changing Practices in relation to increased participation in (Mathematics) Education more broadly

2.2.1 Changing forms of participation in the practice of discussions on education.
2.2.2 Changing forms of participation in a range of school activities.
2.2.3 Changing roles in relation to the broader professional community.

Of course teachers' learning influenced, and was influenced by, a wide range of other activities in teachers lives, as is clearly captured by Karl in an interview in June 1999. In this interview Karl defends his participation in PLESME to his colleagues by arguing that it is about more than simply learning about teaching:

> The other teachers (at his school) were teasing me. Like one of the teachers says he does not understand why we do these workshops…But his argument was that he was going to leave teaching so he's going into computers now and he is more interested in that… I told them

> actually that 'I'm preparing for the future, what are you doing?' They said 'no we know all the things that you go and attend' and I said 'that's not true, it's 2005 you haven't dealt with it yet.'
> MG: But it is interesting because they don't see teaching as their long term profession so there is not an interest in learning it for them. And I suppose to some extent it makes sense if…
> Karl: It's more than that, I think it, the programme develops you as a person and you can take it to all kinds of areas of your life. Its not just teaching centred I think. It's a new way of looking at things. They are going to have children, and they have to have an idea in which direction we are going. We're still a part of a society and influence it. That's my viewpoint anyway [Karl Interview, June 1999].

Similarly other teachers gave anecdotal[5] evidence in interviews and discussions about how their learning was influencing their lives more generally. However, such changes were not a focus of this study. I therefore focus here on changing practices only in relation to *mathematics* teaching and (mathematics) *education* activities more generally.

2.1 Changing practices in relation to mathematics teaching

2.1.1 What teachers said about their changing Mathematics Teaching Practices

In resonance with teachers' changing understanding (*meaning*) of the new curriculum and of learning, teachers gave a range of evidence of their changing classroom practices. As illustrated in the vignette of Ivan (Chapter 6), the main take-up in this respect was in terms of adopting more learner-centred practices, relating lessons to real life contexts and more conceptual engagement with mathematics. For example, in response to the instruction: "Discuss the way in which your classroom practice has changed over the period of this year" [Questionnaire, November 1999] teachers wrote:

> I tend to be more open minded as to other ideas and methods of teaching. I tend to listen to the pupils opinions more frequently; giving them more room to express their ideas. I am more aware of what I say and how I say it… [Karl Questionnaire, November 1999].

[5] By anecdotal evidence I mean personal stories that teachers told me in an interview or in an informal discussion to explain something.

> The focus is now more on the learners than the teacher (educator). Learners work more in groups than as individuals…[Puleng Questionnaire, November 1999].
>
> Learners are now free to can ask where they do not understand…I have really enjoyed teaching this year…[Rosina Questionnaire, November 1999].
>
> Questioning techniques have improved and pupils assisting one another by attempting to answer the friends' question. Lessons are more learner orientated. [Delia Questionnaire, November 1999].
>
> Learner-centredness has improved in such a way that conjectures can be confronted head-on even by the normally passive learners… [Cedric Questionnaire, November 1999].
>
> The practice has tremendously changed because now one approaches the learners with confidence and with understanding…. I can now command learners to explain their reasoning and as to how they arrived at the answer. The interaction between myself, and the learners, is such that it will allow room for insight, analysis and understanding on their part. This practice has made me to be aware that learning is a dual activity in that I learn they also learn too [Moses Questionnaire, November 1999].

The quotes above also indicate teachers' changing understanding of the nature of learning (and not only of teaching). The last sentence in the response by Moses particularly captures this shift. Moses restates this point in the questionnaire of July 2000 (see below). This shift in teachers' understanding of the nature of learning was explicitly noted by several teachers in the interviews of November 2000 in relation to explanations of changing confidence. This is discussed further in Part 5 of this chapter.

Later in response to the question, "What changes, if any, have you experienced in your classroom practice over the past two years?" [Questionnaire, July 2000], teachers similarly indicated that their *primary* changes were in relation to the adoption of more learner-centred practices as evidenced in the responses below:

I have become more "reflective" in my teaching practices. I tend to listen more and value every childs' opinion…[Karl Questionnaire, July 2000].

Able to work with learners in groups. Give learners a chance to say their say… Allow a healthy interaction amongst learners [Puleng Questionnaire, July 2000].

That thing of saying No to learners when maybe the answer is wrong is no more there. The child must explain how he/she got to the answer [Rosina Questionnaire, July 2000].

My teaching approach is more learner–centred. My learners seem to enjoy Mathematics. They are free to discuss their methods, fears and problems with me. They are more active, enjoy the group-work and games which we do in class [Beatrice Questionnaire, July 2000].

I have more confidence in presenting the subject and in asking questions that are exciting to pupils… [Ivan Questionnaire, July 2000].

I used to believe in giving the information and rules to the pupils. I was the only one teaching. Now I believe they must find answers and solutions to the questions… The pupils must now ask the question – why is it so? I never used group-work, but now I use it, where it is possible. Understanding of the concept is more important than the rule! [Elaine Questionnaire, July 2000].

I am now in a position to make my own maths programme with confidence…I had also learnt to learn from my learners and to make it a two-way type of affair. I am now giving them platform to express their views [Moses Questionnaire, July 2000].

Other changes in classroom practice noted by teachers in this final questionnaire involved increased: reflection on lessons (3)[6], confidence (7[7]), planning (1), design of their own lessons and worksheets

[6] The numbers in brackets represent the number of teachers who noted each listed change.
[7] Three of the teachers expressed this confidence using the term 'easier' and one other teacher used the term 'able' the other three used the term 'confident'.

(2), enjoyment of lessons by the teacher (3), relevance to everyday life and interest for learners (4) and the use of a variety of methods (1).

From the above it is evident that, aside from change towards more learner-centred practices, increased confidence is the most frequently noted change (by seven out of the ten teachers) in response to this question. Only one teacher, Moses, noted increasing confidence as one of the changes in classroom practice in the November 1999 questionnaire. This would seem to imply that teachers' awareness of confidence in mathematics teaching developed largely only in the second year of teachers participation in PLESME. To illustrate this shift in confidence I have provided Sam's complete response on these questions for November 1999 and for July 2000 below:

> I have experimented with groups' sizes etc. Pupils talk and explain to their peers. It is not so "quiet" in my classroom. I make better notes after and during the lessons. It is not so teacher-centred anymore. I will listen to different ways of getting to an answer. I know my pupils' strengths and weaknesses and I can plan lessons accordingly. I know in what direction to move with my pupils. I know where they are – where to go and how I am going to get there [Sam Questionnaire, November 1999].

In the second questionnaire Sam also noted a change in his attitude towards teaching. He described his changing practice using 'affective' terms such as *relaxed*, *better, confident* and *enjoy*:

> As a teacher I am much more *relaxed*[8]. I try and do things right the first time. Lead pupils to the answers and concepts. Understand that not all my pupils are English first language. I use a "math" dictionary all the time (and my pupils use this too). Link maths to children's everyday lives. I reflect on my lessons afterwards. Try new and different things all the time. I am a ten times *better & confident* than what I was 2 years ago. I *enjoy* my "maths" teaching so much "I will probably do it for a long time to come" [Sam Questionnaire, July 2000].

[8] A reminder that I have used italics in both verbal and written quotes of teachers to draw the reader's attention to those parts of quotes that particularly support the arguments I develop.

Clearly all teachers had, in their own views, changed their classroom practices. This was evidenced by what teachers said in interviews and wrote in questionnaires. These changes were also present in teachers' classroom practices as evidenced from lesson observations and videos.

2.1.2 Observed Changes in Mathematics Teaching Practices

Videos of teacher lessons were taken at three different periods: March 1999, October 1999 and May 2000. Detailed notes were taken of the lessons with a particular focus on the mathematics content of the lesson, the style of the lesson and 'critical incidents' for discussion in reflection sessions with teachers after the lesson (discussed in Chapter 4). In addition, lesson schedules (see Appendix 8) were completed. The lesson schedules helped in recording aspects of the lesson relating to:

1. Lesson introduction
2. Whole class teacher-pupil interaction
3. Group/pair work
4. Teacher questioning
5. Verbal participation with the teacher
6. Clarity of explanations from teacher
7. Dealing with misconceptions
8. Content knowledge and confidence
9. Pupil resources
10. Use of language in the public domain
11. Conclusion

Movement on Item 1 generally indicated a greater inclusion of everyday contexts into lessons in order to arouse learner interest. Movement on Item 10 generally indicated that lessons were concluded with a brief summary and homework. These items are not discussed in detail. Below I have analysed the summary tables of teachers in relation to three primary aspects of classroom practice that are of particular importance for this study.

First, in relation to the methods used in the lesson (Schedule Items 2, 3, 9 and 10);

Secondly, in relation to the intersection of changing methods and engagement with mathematical concepts (Items 4, 5 and 7); and

Thirdly, in relation to the teachers' mathematical knowledge, explanation, confidence and competence (Items 6 and 8).

The observation schedule was not designed [9] with the above three aspects in mind. In retrospect the schedule should have been structured in relation to these three aspects and other items could have been included. For example, the amount of written learner activity could have been included. The schedules did however provide some useful information in terms of showing general trends in the take-up of new curriculum ideas in relation to teachers' classroom practice.

A summary of teachers' classroom practices, as recorded on the observation schedules for the three observed lessons, are given for each teacher in Appendix 10. These are analysed in relation to the three primary aspects identified above:

First, an analysis of schedules in relation to methods used:

The summary tables indicate that the greatest changes for teachers (between the first and the third lesson, although often shifts had already occurred by the second lesson) were in relation to observation items 2, 3, and 9. These items are given below:

2. Whole class teacher-pupil interaction

Totally controlled by the teacher.	Predominantly controlled by the teacher.	Teacher creates opportunity for pupil questions and pupil-pupil interaction.	Teacher actively encourages pupils to question and interact with each other.

3. Group/pair work

No group or pair work at all.	Very few pupils question each other secretly and quietly.	Pupils are allowed to work together.	Pupils are organized in such a way to facilitate pair/group work. High frequency of pupil discussion.

9. Pupil resources

Pupils only use their exercise books and do work from the board.	Pupils use text books Or (not and) Pupils participate in board-work[10].	Pupils use textbooks and also participate in board work.	Pupils use materials in addition to textbooks (worksheets maths apparatus etc.).

All teachers shifted on each of these items (except in cases where teachers had been recorded in the fourth column from the first observed lesson) by at least one category. Five of the teachers shifted by two or more categories on Item 2, four shifted by more than two on Item 3 and three shifted by two or more on Item 9. Movement on these items resonated with the take-up of more learner-centred practices. According to Cuban (1993) an increase in learner talk, more instruction to individuals and small groups, varied instructional materials, and arrangements that permit learners to work together or separately are some of the indicators of more learner-centred practices (see Chapter 5). Movements towards these practices are incorporated in Items 2, 3, and 9 above.

While it is important to note the shifts that took place in relation to the use of language in the classroom, this was not a focus of this study and it is therefore dealt with briefly and superficially. For a deeper engagement on language practices in multilingual mathematics classrooms in South Africa see Setati (2002) and Setati & Adler (2000).

For all of the Soweto teachers (see the summary tables of the first five teachers in Appendix 10) there was an increase (by at least two categories) in the use of languages other than English in teaching mathematics as recorded on Item 10 given below:

10. Use of language in the public domain

Teacher only uses English.	Teacher mainly uses English and seems to discourage the use of home languages, but does use it for discipline etc.	Teacher mainly uses English but switches sometimes in order to facilitate conceptual clarity.	Teacher switches appropriately between mathematical English and other languages to meet the communication needs.

[9] The forms were part of the Further Diploma in Education research project that was based at the University of the Witwatersrand (see Adler *et al.*, 1999). I was part of a team of people who developed these forms and saw these as useful at the start of the research.

[10] The 'or participate in board-work' was added in later when analysing classroom observation schedules and lesson notes. This change was due to the fact that some teachers got learners to participate in board-work but did not use textbooks or give exercises (for example, in Ivan's second lesson). Thus placing them in the third category was misleading.

For almost all the learners and teachers in the Soweto schools English was not their main language. In many cases it was not even a second language. The debate surrounding 'language of instruction in the mathematics classroom' was dealt with in PLESME workshops, and teachers were encouraged to switch between languages when they felt it appropriate. This shift in the use of language in the public domain supported more learner-centred practices since using learners' home languages facilitated learner discussion and helped teachers to access learner meanings more easily.

There are no shifts recorded in the use of language for the Eldorado Park teachers. The historical explanation for this is that before 1994 elections, Eldorado Park was a so-called 'coloured township' and its schools only accommodated coloured learners. Schools were usually dual medium and taught separate classes of English and Afrikaans learners (i.e. the two languages of their learners and teachers). After 1994 the racial composition of learners in the Eldorado Park schools began to change. During the period of this study the racial composition of learners changed at a rapid rate. Many learners from Soweto schools moved to Eldorado Park schools during this period largely due to the perception that these schools offered a better education. After all, under apartheid these schools and teachers were privileged in relation to resources in comparison to their Soweto neighbours. However, the racial composition of the teachers did not change at the same rate and therefore all of the Eldorado Park teachers in this study were either coloured or white and spoke only English and/or Afrikaans. The lack of change on this item for the Eldorado Park teachers therefore does not indicate an unwillingness to change their language practices, but rather an inability to meet the language demands of their 'new' learners.

Secondly, an analysis of schedules in relation to the intersection between learner-centred practices and mathematical meaning:

Other changes in classroom practice worth noting related to the interface between more learner-centred practices, engagement with learner meanings and misunderstandings, and the mathematical content of the lessons. For example, in the item of teacher questioning (below), all the teachers showed movement (by one category) to the right on this item.

4. Teacher questioning

Does not ask questions at all.	Asks questions that only require recall, repetition or simple factual questions.	In addition asks questions which require some explanation or justification.	In addition asks questions that challenge and extend intellectual demand.

Similarly for Items 5 and 7 (included below) all teachers (except Sam and Delia who were recorded in the fourth block in the first observed lesson) showed movement of between a half, and one and a half categories.

5. Verbal pupil participation with teacher

No verbal pupil participation.	Pupils participate only in response to teacher questions – one-word answers.	Pupils participate in response to teacher – give simple rule based answers.	Pupils respond to questions and give answers that demonstrate relational understanding and volunteer more than is asked.

7. Dealing with misconceptions

Does not notice misconceptions.	Notices and gives the right answer.	Notices and engages in some kind of rule based explanation.	Notices and uses explanations which facilitate conceptual clarity.

Thirdly, analysis of schedules in relation to the mathematical knowledge, explanation, confidence and competence:

The shifts discussed above can be related to shifts in mathematical knowledge as evidenced by movement (of between a half, and one and a half categories) on Item 6 and Item 8 below:

6. Clarity of explanations from the teacher

Unstructured or inaccessible explanations	Relatively structured and accessible explanations	Clear, structured and accessible explanations	Clear, structured and flexible explanations which arouse interest. (eg linking to pupil experiences)

8. Content Knowledge and Confidence

Very poor knowledge of content area	Basic knowledge of content with some inaccuracies	Sufficient knowledge of content area and relatively confident	Good knowledge, shows an ability to relate it to other ideas/concepts. Confident

It is problematic to deduce that there was a change in teachers' mathematical competence and confidence from only a few observed lessons since inaccuracies can be tied to the specific content of each lesson. The summary tables for teachers did however show some movement on Item 8. Similarly shifts in Item 6 indicated some change in teachers' mathematical knowledge. These shifts were primarily in relation to teachers' increasing attempts at deeper engagement with mathematical concepts and meanings. Thus, for example, in Ivan's third lesson (see vignette in Chapter 5) there were no evident errors or misconceptions in his dealing with the topic of division of fractions. While this could be attributed to Ivan having a solid understanding of fractions (in comparison to his misunderstandings related to the classification of quadrilaterals), it is more likely that the absence of errors and misconceptions is due to Ivan's use of resources (in this case two textbooks) in order to help him to structure and prepare his lesson. This use of resources resulted in increased confidence and competence in dealing with the mathematical content of the lesson.

Similarly, it is likely that for other teachers the improvement in relation to mathematical explanation, competence and confidence were as a result of increasingly drawing on a wide range of resources to structure their teaching and assist their own understanding of mathematics. These resources therefore shaped teacher practices.

As teachers participated in PLESME and in the practice of implementing new curriculum ideas, they formed mathematical trajectories that converged with their trajectories of learning to become confident professional mathematics teachers. These mathematical trajectories were formed within PLESME and in their classroom and school communities. The data, in this chapter shows that all teachers in this study had similar trajectories in the sense that they all were on a path to becoming professional mathematics educators. The data however, also shows differences in teachers' mathematical trajectories. These trajectories incorporated the past and the future in negotiating the learning that occurred during the PLESME period in relation to changing meaning, practice, identity, community and confidence.

For some teachers (for example Delia, see schedule in Appendix 10), deeper engagement with mathematical meanings was powerfully supported by the introduction of more learner-centred practices, such as: asking questions that required learners to explain their thinking (Item 4); getting

learners to demonstrate relational understanding (Item 5); getting learners to question and interact with one another (Item 2), and by strong mathematical competence and confidence (Items 6 and 8).

In some cases however, where teachers had entered PLESME with limited mathematical competence and confidence, tensions arose between adopting more learner-centred practices and engagement with mathematical meaning (for example, Rosina, see schedule in Appendix 10). The relationship between implementing new forms of teaching practices and mathematical competence are important in that they determine the mathematical learning trajectory of teachers. That is, they determine the range of possible mathematics learning (in relation to the development of mathematical competence and confidence) given a particular learning situation. In the case of this study the learning situation involved participation in PLESME and participating in the practice of implementing new curriculum ideas.

In the following section I focus on the differences in mathematical trajectories of two teachers in the context of implementing new curriculum ideas in a mathematics classroom[11]. I expand on this relationship with the aid of two brief vignettes in 2.1.3 below.

2.1.3 The relationship between mathematical trajectories and new forms of teaching practice

I have chosen extracts from the mathematics lessons of Delia and Rosina in order to illustrate differences that result when different mathematical trajectories (involving different mathematical competences and confidences) combine with pedagogical learning trajectories (involving understanding and implementing more learner-centred practices in which teachers perform the role of guiding groups of learners to 'construct' and develop mathematical meaning). While many other lessons could have been chosen to illustrate the relationship between teachers' mathematical trajectories and their use of more learner-centred methods, I have chosen these extracts from Delia and Rosina's lessons for the following reasons:

[11] In Part 3, I explore the relationship between teachers' mathematical trajectories and identities beyond the classroom practice.

- Rosina and Delia are at the 'opposite ends' of the 'mathematical competence' continuum as defined by their mathematics histories. Of the ten teachers in the sample, Rosina had the least mathematics training while Delia was the only teacher to have studied mathematics at university level. Their mathematical histories, that continuously shape their path of mathematics learning, are therefore very different.
- Both lessons aim at guiding learners to 'construct' mathematical formulae after providing learners with concrete objects to manipulate in order to aid such constructions, and, both lessons involve group work. These similarities (in the aims and structure of the lesson) support a comparison between the nature of mathematical competence and new forms of practices in the two lessons.
- The extracts in these lessons illuminate that there is a complex relationship between various forms of learner-centred practices and the teachers' mathematical competence and confidence.

It is important to note that it is beyond the scope of this thesis to explore this complex interrelationship in great depth. To do so would require detailed transcripts and thorough analysis of many more lessons and a wide range of types of lessons. Rather, what I hope is illuminated by these vignettes is that there is a complex relationship between these two. And furthermore that this complex relationship is indeed affected by (and in return affects) the mathematical trajectories of teachers (as defined by the dynamic interaction between the past, present and future), in relation to teaching mathematics, for the teachers in this study.

I structure my commentary on Rosina and Delia's lessons around four aspects that help to illuminate the relationship. These are:

1. The nature of the task (the clarity and structure of the task).
2. The validation of learner constructions and methods.
3. The use of 'real-world' objects in the lesson.
4. The teacher reflections on the lesson.

The extracts from the lessons are elaborated in the narrative vignettes below:

Narrative Vignette on Rosina's third observed lesson

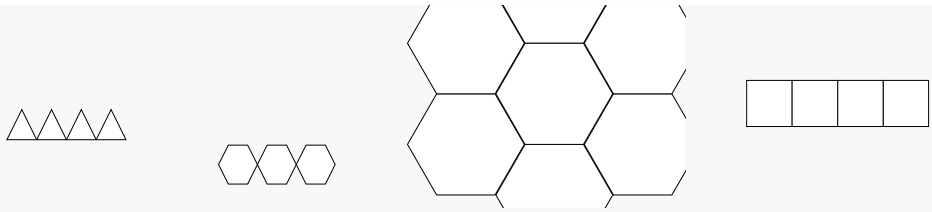
Rosina teaches in a relatively small primary school in Soweto (four hundred students and eight teachers). She spent two years training to be a primary school teacher. The last time she studied mathematics was when she was at school where she obtained an F symbol in commercial mathematics for Grade 12. She has twenty years teaching experience. The extract is from a Grade 7 lesson on patterns. The lesson took place on the 24th May 2000. There were thirty-five learners in the class seated in groups of six.

Rosina began the lesson by asking learners questions about patterns they had seen in real life. She handed each group of learners a piece of fabric and asked the class questions about the shapes that had been used to make the patterns on the cloth. (Some were dots, strawberries, flowers, tessellating hexagons & squares etc.) She wrote the names of the various shapes on the board. Thereafter Rosina held a discussion with learners about the different values of the fabric and argued that the more beautiful the pattern the more expensive the fabric. She explained that they were now going to use numbers to make patterns.

Rosina gave each group a pile of straws, a pile of matches or a pile of cubic blocks with which to make their own patterns involving, either squares, hexagons or triangles. As she gave each group a pile she instructed them:

You make your own pattern using squares. (Moving on to the next group)
You make your own pattern using triangles. (Moving on to the next group)
You make your own pattern using hexagons. (Moving on to the next group)
You make your own pattern using squares. (Moving on to the next group)
You make your own pattern using triangles. (Moving on to the next group)
You make your own pattern using hexagons. (Moving on to the next group)
(To the whole class) Make your own patterns. It must be one big pattern in the centre of the table. You are forming your own patterns. It must be one big thing. Let it join, it must be a big thing. Start building! Start building!

The groups came up with a wide range of patterns. Some were tessellations of shapes covering the desk while others were rows of shapes joined in different ways. Some of these are shown below:



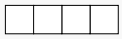
While learners were busy making their patterns with the straws, matches or rows of blocks, Rosina moved around from group to group. Where the patterns were not constructed in such a way that each shape shared at least one and at most two sides with other shapes (as shown in the squares above) Rosina would say to the groups:

You must join the shapes. Join the squares. Join the triangles. It must be one big shape. You build up from here, go on like that. It must go that way. Continue, you must go that way. You must go that way. You must go that way. Can you see its one line going that way? Only one line!

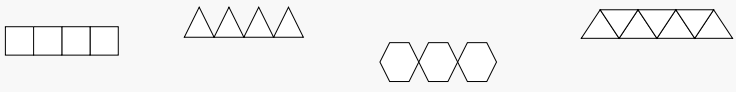
As Rosina said this she built some of the shapes for learners to show them how to proceed. Still many learners continued to add shapes in all directions so as to create a tessellation pattern rather than a straight pattern of shapes in one row. Seeing that learners were struggling to understand the type of patterns that she had in mind Rosina brought the classes attention to the board.

Rosina: Everybody stop. Bernard's group were making squares. How many did you make?
Group: Four

Rosina then drew four squares as follows on the board:



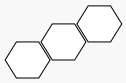
Similarly she drew the patterns of other groups who had constructed their shapes in a row. She then had the following on the board:



She asked the groups how many blocks they had used to make each of the patterns that she had drawn on the board. [Note: What Rosina meant by ‘blocks’ was the ‘number of sides’ (i.e. in this case the number of matches, straws or sides used in learners’ patterns).] Each group gave their answers and she then asked them to say how many sides were used to make one hexagon, one square and one triangle. And she wrote on the board:

1 hexagon = 6
1 triangle = 3
1 square = 4

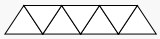
Rosina then asked learners if she built two hexagons “like Jeremy and the group did” how many sides the second hexagon would use. She drew the following on the board:

and pointed to the second hexagon in the pattern. 

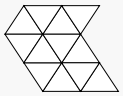
The learners responded with ‘5’. Rosina pointed out that the 1st one is 6 and the 2nd is 5 and the 3rd is 5 and then wrote 6 + 5 + 5 + 5 + … She followed the same process of asking learners similar questions for the pattern of squares (joined in the same way of sharing at least one and at most two sides). She also asked learners to explain why they gave the answers they did. For example, why the second square in the pattern only needed three sides while the first needed four sides.

Rosina then proceeded to a group who produced the following pattern for triangles:

Rosina responded, ‘No. They must join like this. They must join like this’. As Rosina said this she changed the groups pattern to look like this:



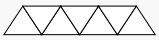
Rosina then instructed the whole class to change their patterns to be triangles “so that it is in one long row”. The groups then proceeded to change their patterns but one group of learners once again proceeded to tessellate the triangles and constructed the following:



Rosina moved around from group to group and where learners had constructed patterns with traingles that did not satisfy the condition that each shape shared at least one and at most two with other shapes she said:

Not correct. Not correct. No wrong, try again, try again. No it must be one, It must go that way. No not that one, try again, try again. You are making a pattern with triangles. Lindi is doing the right thing. Thapelo’s doing the right thing. No try again. (The group who built the tessellating triangles above respond in disbelief ‘aaah’).

Rosina then got Thapelo to come and show his pattern of triangles on the board. He drew them as follows:



She then instructed the class to ‘do exactly what Thapelo has done’.

Rosina then explained using this drawing that the number needed for each triangle in the pattern was 3 + 2 + 2 + 2. She asked learners to explain what was happening and challenged them to think about how many ‘sticks’ would be needed in, for example, 7 hexagons.

Once all the groups had constructed a ‘correct’ pattern of triangles. Rosina handed each group a worksheet to complete and said to the groups ‘I’m giving you two minutes to do that’. The worksheet contained the following:

Fill in the tables:

Squares	10	11	15	20	100
Number of[12]:					

Triangles	10	11	15	20	100
Number of:					

Hexagons	10	11	15	20	100
Number of:					

Learners were then given a chance to complete the tables and Rosina walked around checking that the groups understood the task correctly. Learners were given about ten minutes for this activity and many groups had not completed the first table. Rosina got learners from groups that had completed the tables to come to the board to explain how they got their answers. Learners came to the board and showed a wide range of methods for finding the number of sides in the different tables. Some used the long method of repeatedly adding (for example adding 2 nine times to 3 in the case of the number of sides in ten triangles in a row) while others said that they had found a short cut and explained that method. For example, in the case of the number of sides in the 11^{th} square a learner wrote on the board: (3x11) +1.

The rest of the lesson dealt with explanations of the various short cut methods that learners used to fill in the tables. Time was running out, approximately 1 ½ hours had already passed.

The rest of the lesson is not important to this story except in relation to understanding that Rosina's aim was to get learners to derive 'formulae' for working out the number of sides in a row of shapes

[12] 'Number of' referred to the number of sides in each number of joined shapes. This was not however clear on the worksheet but was clear from what Rosina had done with the class on the chalkboard.

joined in a particular way. She wanted learners to find a general formula to calculate the number of sides in any length of a row of shapes joined together in a particular way.

Commentary on Rosina's lesson

1. The nature of the task (the clarity and structure of the task)

The instructions that Rosina used to guide learners in the lesson were very open-ended. For example, Rosina asked learners to discuss what they saw on the fabric she gave them and later instructed them to make patterns with triangles, squares and hexagons. Both these instructions are very open-ended and indeed led to a wide range of responses by learners. The 'openendedness' of the instructions was not a problem in its own right but rather the problem was the mismatch between the 'openendedness' of the instructions and the aims Rosina had for the lesson. The goal of the activity (of constructing patterns) was clearly fixed (i.e. to design one type of pattern that generates a particular formula), but the communication of the task implied that it was open. Thus the openness of the instruction 'make your own pattern' created a problem in that learners constructed patterns Rosina had not expected. These patterns could not be applied to the worksheet she had prepared (as in the tessellation patterns) or in the cases where they could be applied to the prepared worksheet Rosina was unable, or possibly not confident enough, to explore (without prior preparation) the implications of such a change of pattern. That is, Rosina did not realize (during the lesson) that the triangles joined by one group in such a way that they touched each other at a point but did not share sides could also generate a mathematical formula (this was discussed with her in the reflection session). Even had Rosina worked with this type of pattern it would have made it difficult to work with the class as a whole since the answers would be different for each group, not only depending on whether they used triangles, squares or hexagons, but also depending on how they joined the shapes in a row. Clearly in order to make the lesson more manageable Rosina needed to guide the learners to construct patterns 'in the same way'.

A problem with the ambiguity of the instruction to build patterns is that most of the lesson time was spent on pushing learners to construct the right pattern. This meant that very little time was left for the activity of generating number patterns from picture patterns and finding a formula. This activity was the core mathematical activity and yet, due to time restrictions, Rosina tells the learners that they only

have 2 minutes for this activity. While she gave them more time, many learners had not had enough time to work out a method or formula for the number of sides in the 100th pattern.

By forcing learners to change their patterns and by saying 'wrong pattern' to patterns that were different to those that Rosina was expecting, Rosina communicated to learners that there was a specific pattern that was the 'right' pattern and a large part of the lesson therefore became figuring out what pattern Rosina had in mind. Rosina was unable to find a way to express to learners exactly what she wanted. She did not have the mathematical language at that point to express to the learners that what she wanted them to build were patterns in which the *same shape was repeatedly joined in a row* in such a way that every shape in the row shared *at least one* and *at most two sides*[13]. Rosina herself noted this difficulty in her reflection on the lesson, discussed below.

2. The validation of learner constructions and methods

Forcing learners to redo their patterns had the effect of invalidating learner constructions. Validating these patterns required some flexibility in the direction of the lesson and Rosina did not have the mathematical experience, competence or confidence to identify 'on her feet' the mathematical content of the patterns that learners created. To validate learner constructions Rosina needed to be able to identify the mathematical value and content of learner constructions. For example, had Rosina noted that the patterns were tessellations (which has recently been introduced as a new content area into the MLMMS curriculum) she might have responded by saying 'those are beautiful tessellations, we will explore the mathematics of them later in the year'. Similarly had Rosina noted the way in which the other patterns of shapes in a row produced different mathematical formulae she might have been able to validate these by saying 'yes these patterns will also generate a number pattern and we can explore these in tomorrows lesson (or after school), but for now lets all investigate the same type of pattern'. During the lesson, however, Rosina was not aware of these possibilities. It was only in the reflection of observing the video that through discussion Rosina became aware of the terminology of 'tesselation' and the possibility that other patterns also produced mathematical number patterns from which formulae could be derived.

[13] It is also likely that Rosina's lack of fluency in English, not being a first language English speaker, added to the difficulty of finding the terminology to communicate to learners exactly what she had in mind.

Due to the closed nature of the intended task, Rosina's inability to identify the mathematics that could be extracted from different learner patterns, and due to Rosina's struggle to communicate clearly her intentions to learners, Rosina was unable to validate the 'unexpected' patterns that learners constructed. While Rosina communicated an 'open ended' investigative style of exploring patterns, as is encouraged by the new curriculum, the wide range of patterns that learners constructed when given this freedom was unexpected. Rosina's inability to 'mathematise' each group's construction forced her to reject these constructions and to push learners to simply reproduce the patterns that she had in mind.

There is the possibility that Rosina experienced a tension between wanting her lesson to appear open-ended and flexible but not intending or expecting the lesson to proceed in any other way than was expected. In this respect it might have been more appropriate for Rosina to communicate to learners at the start of the lesson exactly how the patterns should be built. She could have done this by drawing the patterns on the board at the start and this would have enabled her to spend most of the lesson time on the mathematical goal of deriving formulae. But would this have appeared too traditional and not sufficiently learner-centred?

3. The use of 'real-world' objects in the lesson

The tessellation patterns that learners came up with were visually impressive and were influenced by the tessellation pattern of hexagons that learners had seen on a piece of fabric given to them at the start of the lesson. In this sense the real-life context of the fabric guided learners away from constructing rows of shapes that generate the type of mathematical number patterns that formed the basis of Rosina's lesson and lessons to come. Rather, this context guided some groups of learners to explore tessellation patterns with a focus on aesthetic value (important for the sale of fabrics as discussed at the start of the lesson).

Tessellations are included in the new curriculum at the primary school level. Rosina was however not aware of this and was unable to verbalise the distinction between the tessellation patterns on the fabric and the patterns she was working with in order to generate number patterns. This inability to clarify the difference between the patterns on the fabric and the type of patterns that the class was going to

explore led to the complete separation of the initial fabric activity from the rest of the lesson. Furthermore those groups who made a connection between the two activities were disadvantaged in the sense that this connection led to the construction of 'incorrect patterns.'

4. Rosina's reflections on the lesson

In Rosina's written reflection she expressed the difficulties she had as follows:

> Learners had a diversity of patterns. That made me understand that my instruction was not understood. After one of the pupils did what I wanted, I went on with the lesson without any problem. *The textbooks that we use do not state clearly the instruction.* We as teachers should come up with a way a learner can be able to understand. *Tesselation was done very well but they were not able to count the number of sides…* They (learners) really participated in this lesson. I could feel that the new method of teaching have really changed my way of working in a class situation…The lesson was interesting. It was just that the patterns were done differently. My instruction should have been 'make a pattern that would make your diagram share a side'. The patterns were good and interesting. At the end they managed to make them share a side. We were able to count the number of sides. The learners could even find a formula. Counting the sides of triangles joined together (tessellations) was not the same as counting the sides of the triangles which share a side [Rosina's written reflection of her lesson of 24/05/00].

There were of course many positive aspects of Rosina's lesson, as noted in fieldnotes and by Rosina herself in her reflection above, especially in relation to learner activity and enthusiasm. These are however not important for the discussion at hand. The aspect that I wish to focus on is the tension between Rosina's intention to conduct a relatively 'open' investigation, introduced through analysing patterns on fabric, and Rosina's need to narrow down the activity so that what learners constructed matched her own understanding, and her preparation, of the activity.

My hypothesis is that Rosina's mathematical trajectory (her experience, competence and confidence) limited her ability to approach the lesson with flexibility and work with learners' constructions. It is likely that Rosina's lack of clarity on the direction of the task is a product of her own mathematically

limited experience with the derivation of numerical patterns from shape patterns. Without more experience and an understanding of the way in which different types of patterns can generate a wide range of number patterns it was not possible for Rosina to work with the task as an open investigation. While Rosina showed confidence in using ideas from a newly published textbook, she explained that the textbook did not help her provide a clear instruction to learners. It is also clear that this text did not assist Rosina in understanding the derivation of number patterns from shape patterns more generally.

On the other hand, in the second part of the quote above, Rosina points to the successes of her lesson in relation to incorporating new curriculum methodologies in order to increase learner interest and participation. At this juncture, in relation to classroom practice, it seems that Rosina has foregrounded her pedagogical learning trajectory even while she struggles with the mathematical learning afforded by the interaction between her mathematical history and implementing new ideas in the classroom situation.

In sum, Rosina's trajectory of mathematical learning, in relation to her learning within the practice of teaching mathematics, was influenced by her mathematical history in such a way that mathematical learning was placed in the background of more prominent pedagogical learning.

Narrative Vignette on Delia's lesson

Delia teaches in a large high school in Eldorado Park. She spent four years training to be a high school teacher specializing in Biology. While she did not intend to teach mathematics she studied Mathematics 1 at University level and had been teaching Mathematics for ten years. The excerpts are taken from a Grade 9 lesson on patterns. The lesson took place on the 19th August 1999. There were thirty-five learners in the class seated in groups of six.

Delia explained (in the reflection session) that her purpose of the lesson was to try out an idea about how to relate the concepts of volume and capacity using everyday objects. She had discussed her idea of how to do this with her colleague Sam and myself before a PLESME workshop.

Delia began the lesson by handing out 1-litre 'Liquifruit' boxes (a rectangular prism box holding 1 litre of fruit juice) to each of the groups. Each learner was also handed a photocopied worksheet. The worksheet contained various exercises involving finding the area for different shapes (circles, rectangles, and triangles) and finding the volume of various three-dimensional objects (rectangular prisms, cylinders, triangular prisms and stacks of cubes).

Delia revised, through questioning, the methods for calculating the areas of squares, rectangles, circles and triangles. She emphasized that before they could move onto calculating the volumes of different prisms they needed to know these areas. Learners then completed the part of the worksheet that dealt with the areas of shapes.

Delia engaged learners in a discussion of the distinction between squared units used for measuring areas and cubic units used for measuring volumes (i.e. cm^2 and cm^3). To assist learners in grasping this distinction and to understand why cubic units are used for volumes, she showed the class a wooden cubic centimetre. She asked the class how many sides it had, why it was a cube and what they noticed. Learners used a range of mathematical language to say what they saw and Delia linked this language to the concrete object. She used this discussion as a basis from which to discuss the difference between the volume of solids and liquids and introduced the terminology of capacity to assist learners to understand the distinction:

Delia: Now capacity would be like an empty box. (She holds up a 1-litre Liquifruit box). Like the capacity of this box, how much liquid could get into this box? It will hold one litre of liquid. But in the case of a solid we talk about?
Class: the volume
Delia: But I want to show you something interesting. You have these little cubes in front of you. Take one. Measure them. (The learners lift the wooden cubic centimetres and measure the lengths of the edges).
Delia: Okay. So they measure?
Class: 1cm by 1cm by 1cm.
Delia: Okay. Right at the bottom of your worksheet it says 1ml = $1cm^3$. But what does this mean? I've got a syringe here. I am going to show you what 1ml is. (Delia shows the class 1ml of liquid in the syringe and dispenses it into a teaspoon. She moves around showing the liquid in the teaspoon to each of the groups). But if we have to measure a solid we would use cubic centimetres.

Delia then related this to the Liquifruit box and emphasized that it could hold one litre of any liquid. She reminded learners that 1000ml = 1 litre as was written on the box. She told learners to remember this for the activity later. She then provided a historical explanation for how and why the metric system came about and gave examples of situations where non-metric units can be found, for example, in old or foreign recipes. She pointed to the picture of a baked bean can in the worksheet and discussed why a weight was written on the can rather than the capacity of the can.

Delia then explained to learners that she wanted to focus on the solid aspect rather than the liquid aspect of containers for now. She pointed learners' attention to the exercises on the worksheet that involved finding the volume of various prisms (cylinders, rectangular prisms and triangular prisms). She explained to learners what the base of an object was and lifted a Liquifruit box to show learners that by changing the orientation of the box (and therefore the perception of what constitutes the base) the volume remains unchanged.

Before learners completed this part of the worksheet each group investigated ways to find the volume of a rectangular prism. She handed each group a pile of different slabs of cubic centimetre blocks, for example a slab could measure 5cm x 3cm x 1cm. She structured the investigation in a worksheet as follows:

Step 1: Draw a 10cm by 3 cm rectangle on a piece of paper.
Step 2: Find the area of this rectangle.
Step 3: Using the slabs of cubic blocks build a solid onto this rectangle that is 10cm high.
Step 4: Count the number of cubic centimetres used to build your solid.
Step 5: Compare your answer in step 2 to your answer in step 4. What do you notice?

While learners were busy with this investigation, Delia moved around helping groups complete their solids and encouraging learners to discuss what they noticed about the relationship between the volume of the solid and the area of its base. The learners worked on the activity in groups but every learner worked on his/her worksheet individually to answer the questions relating to the activity.

Once most learners had completed this investigation she asked learners to explain what they had found. The learners explained that the volume of a rectangular prism could be calculated by multiplying the

area of the base by the height. Delia concluded by pointing out that for all rectangular prisms, the volume is always the area of the base multiplied by the height.

She then asked learners to test this formula on their Liquifruit boxes. She encouraged learners to choose a base and to colour it. The learners proceeded to calculate the volume of the boxes they had by multiplying the area of the base by the height. All groups got approximately 1000cm^3.

Delia wrote the different groups answers on the board and discussed the differences. For example, one group had 1000,35 cm^3 and Delia explained that learners did not get exactly 1000 due to predictable inaccuracies in measurement. She then related this back to the liquid (ml) capacity of the box (i.e. that each box can hold 1litre of juice). She then related it back to the wooden cubic centimetres that learners had in front of them and got learners to visualize 1000 cubes fitting into the liquifruit box.

The rest of the lesson involved learners completing different parts of the worksheet and learners were left to complete some of this at home.

Commentary on Delia's lesson

1. The nature of the task (clarity and structure of the task)

Both Delia and Rosina used learner-centred methods involving questioning, concrete manipulation of objects, group and individual work, completion of worksheets and guiding learners to derive a formula. Delia's lesson is, however, structured as a 'closed' activity from the start. That is while Delia's lesson aimed to get learners to derive the formula for a rectangular prism it was highly structured in such a way that ensured that Delia achieved this objective. The groups were given very specific instructions that guided them as to what they should do. This meant that very little time was spent clarifying tasks. Providing a worksheet to every learner (rather than one worksheet to each group of learners) enabled learners to refer to the worksheet individually when they were unsure, and ensured that every learner in each group did some mathematics themselves.

Delia used group-work in such a way that supported the aims of the lesson. Working in groups allowed every learner access to the teaching aids (cubic blocks, Liquifruit boxes, slabs of cubes) that Delia provided. Furthermore working in groups allowed learners to build the 10cm x 3cm x 10cm solid quite quickly and allowed for valuable discussion in supporting learners to 'discover' that the volume was equal to the area of the base multiplied by the height. The group-work did not, however, limit the learners from working individually. This was ensured by the individual completion of worksheets. The group-work was also useful in providing Delia with data about the volume of their Liquifruit boxes (collecting only one measurement from each group saved time). These measurements were used as the basis for the discussion of inaccuracy in measurement and to consolidate the relationship between millilitres and cubic centimetres.

2. The validation of learner constructions and methods

Since the lesson was tightly structured and the instructions to learners were clear, Delia was able to spend most of the group-work time encouraging, checking and commenting on learners' calculations, rather than spending it clarifying what learners should do. Because all groups were involved in the same activity Delia was able to regularly come back to whole class interactions where she consolidated the findings of the various groups and got learners to explain what they had found. In this way learner findings could be used as the basis from which to derive a formula for the volume (and capacity) of a rectangular prism. While the aim of Rosina's lesson was similar in its intention to use the data from learners calculations as a basis from which to generate formulae, this became difficult due to the large amount of time spent clarifying the task.

3. The use of real-world objects in the lesson

Delia brought various everyday objects (liquid containers, cubic blocks and a syringe filled with water) into class and used these as the basis for explaining the relationship between cm^3 and ml. These objects did not simply serve the purpose of arousing learner interest but formed an integral part of the lesson and were crucial tools in achieving the mathematical aim of lesson. They were used to help learners visualize and grasp the difference between volume and capacity and as objects to which one could apply the derived formula. In comparison, the fabric that Rosina brought into the class served the

purpose of arousing learner interest but the connection between this resource and the rest of the lesson was obscure, and in some cases misleading.

4. Delia's reflections on the lesson

In Delia's reflection session after the lesson, she explained that learners had stayed behind after the lesson to discuss some of their findings with her. The structure of Delia's lesson enabled the lesson to flow smoothly and for the focus on the lesson to be on learners grasping the relationships between volumes and capacity, between ml and cm^3, and between areas and volumes.

During the reflection of the lesson, Delia explained that she had prepared the lesson with the support of her husband (an ex teacher) and that she enjoyed the process of thinking and talking it through with him. She explained that she enjoyed preparing the lesson and that this time she looked forward to having it video-recorded. She explained 'I knew I had to put it together and that I didn't have much time to think, but *it came naturally* – I organized it in my head. To be honest *it all came naturally*, your ideas[14], your cubes, the classroom maths textbook' [Delia fieldnotes of reflection session, October 1999].

The quote by Delia emphasises the ease with which she was able to structure an original lesson with confidence. Delia was able to relate complex concepts about volume and capacity to learners with the aid of concrete objects from the everyday world. Delia's focus of the lesson was clearly on developing mathematical meaning and concepts, all discussions and activities were used to support this. This confidence stands in contrast to Rosina who struggled to clarify (both for herself and for learners) the purpose of the activity that she derived from a textbook.

[14] Delia's referral to 'your ideas' needs some clarification. At the start of a PLESME workshop Delia raised the idea that she wanted to teach volumes and capacity in a way that linked it with everyday objects. Delia, Sam and myself discussed her idea informally for a few minutes. Sam suggested using cubic centimetre blocks to show learners that 1000 cubic centimetres will fit into a one-litre container. I provided Delia with some cubes for this purpose. The structuring of the lesson was entirely planned by Delia.

The extract illustrates that Delia integrated new forms of practice (group-work activities, concrete manipulation of objects, integration with everyday contexts etc.) into her lesson in a way that supported her in achieving her *mathematical* aims. I argue that this successful integration was supported by Delia's own mathematical experience, competence and confidence of area, volume and capacity. This mathematical history enabled further mathematical learning to occur through Delia's participation in the practice of preparing for and teaching 'areas, volume and capacity' in a new way. During this process Delia learnt to analyse relationships between area, volume and capacity, she learnt about how these concepts are linked to everyday contexts and she learnt how to use everyday contexts for the purpose of teaching mathematics in new ways.

On the other hand, due to a different mathematical history and resultant mathematical competence and confidence, Rosina struggled to integrate real-life contexts and learner centred practices with the mathematical goals of her lesson. While Rosina was clearly learning about the difficulties involved in bringing real-life contexts into a mathematics lesson and the difficulties of giving learners open-ended tasks, her mathematical learning in the preparation and teaching of the lesson is different to that of Delia's. The mathematical trajectories of Delia and Rosina, incorporating their past, present and future mathematics learning (in the context of teaching mathematics), are therefore different. The table below summarises some key differences between the two lessons:

Table 7.2 A comparison of two mathematics lessons

Rosina's lesson	**Delia's lesson**
Instructions were open to learner interpretation. Learners were involved in a range of different activities. Much of the lesson was spent clarifying instructions rather than on the development of the mathematical concepts.	Instructions were clear. Learners were involved in the same activities. Most of the lesson time was spent working towards establishing key mathematical concepts (as incorporated in the aims of the lesson).
Many learner constructions were rejected because they did not comply with the 'intended pattern'.	Learner activities were validated and learner findings were used as the basis for whole class discussions.
Real life objects were used to arouse interest but were not connected (or in some cases served as distractors) to the mathematical aims of the lesson.	Real life objects formed an integral part of the lesson and were used as resources to support the mathematical aims of the lesson.
Rosina expressed that the textbooks she used did not help her to give clear instructions relating to the task.	Delia expressed that the flow and structure of the lesson 'came naturally'. The lesson was self-designed.

The above vignettes illustrate that there exists a critical relationship between teachers' mathematical histories and their use of new forms of learner-centred practices. The vignettes illustrate that these are intricately connected in a dialectical relationship that jointly produce the nature of the mathematics lessons and jointly produce the learning of the teacher. Delia's stronger mathematical history afforded her the opportunity to foreground mathematics in the structuring of her lesson, and to maintain a mathematical focus while adopting new forms of practices in support of mathematics learning. Rosina's weaker mathematical history obstructed her from foregrounding mathematics in her lesson. Rather pedagogical learning was brought to the fore, and in some cases this focus on new methods was at the expense of mathematical learning.

The vignettes suggest that support for mathematics teachers in relation to implementing new forms of practice should take cognisance of the mathematical histories of teachers and of the relationship between these histories and resultant classroom practices. While the vignettes provide some insight to the nature of the relationship between mathematical histories and teaching practices, this relationship needs further exploration. This issue has been identified by others researching teacher learning from a situated perspective (see Adler *et al.*, in press; Adler 2002) and in various critiques of Curriculum 2005 (Chisholm *et al.*, 2000; Jansen & Christie 1999).

The vignettes of Ivan, Delia and Rosina discussed here and in Chapter 6 illustrate a close connection between the take-up of new practices and the take-up of new teacher roles (which in turn are closely connected with teachers' changing identities). In the next section I discuss the relationship between teachers changing classroom practices and the adoption of new mathematical roles as embedded in MLMMS (discussed in Chapter 2).

2.1.4 Changing roles in relation to changing mathematics teaching practices

Teacher identities also changed in relation to 'who they were' *in the mathematics classroom*. This is evidenced by the take up of new roles inscribed in the new curriculum and in the generic roles for educators (see Chapter 2) in relation to the *teaching of mathematics*.

In Chapter 2, I outlined four mathematical roles teachers are expected to perform in relation to teaching MLMMS as outlined by the new curriculum. These involved:

1. Preparing learners for critical democratic citizenship. In this role the teacher becomes a critical analyser of the way mathematics is used socially, politically and economically in South Africa supports learners to do the same.
2. Assisting learners to become appliers of mathematics in everyday life. In this role the teacher must see the world through a mathematical lens and find ways to exploit this for educational purposes.
3. Apprenticing learners into a ways of investigating mathematics. In this role the teacher becomes an exemplar mathematician and provides insight into the world of 'mathematicians'.
4. Conveying mathematical theorems, conventions and algorithms important for MLMMS in general and for enabling success in the FET band. In this role the teacher becomes a 'custodian' of mathematical knowledge and a 'conveyor' of the practices of the broader community of people with an interest in mathematics.

In the data I collected on the ten teachers in this sample there was very little evidence of the take-up of the first role. In relation to the take-up of the first role that required teachers to adopt critical, politically, socially and environmentally sensitive personas as well as to be able to extract mathematical content from current topical local issues and to develop learning materials based on these issues, only a few teachers embraced this role. While some teachers were able to provide some explanation in interviews of what Specific Outcome 4 (relating to critically interpreting how mathematics is used socially, politically and economically) meant for teaching (see Part 1) there was very little evidence of addressing this outcome in classroom practice.

Only Sam provided (substantive) evidence of this outcome in his teaching practices and in the way he critically analysed the social, political and economic aspects of his world through the use of mathematical tools. This is discussed in the vignette on Sam in Part 3. A possible explanation for the absence of take-up of this role could be due to the absence of available materials that address this outcome. As is discussed in Chapter 2 this outcome is largely absent, or only marginally present, in newly developed learning materials.

All teachers took up the second role of 'assisting learners to become appliers of mathematics in everyday life' (which is clear in each of the included vignettes). However the teachers did this in different ways depending on the resources, including their mathematical histories, available to them. For some, bringing the 'real world' into class was relatively marginal to their lessons and was used primarily as an introduction to gain learner interest (see, for example, Rosina's discussion of fabric) while for others real life applications formed an integral part of the mathematical content of the lesson throughout the lesson (see, for example, Delia's use of various liquid containers in her lesson).

Thus while several teachers drew on resources from outside the classroom in order to supplement their lessons, only Delia, Cedric and Sam designed 'original' learner materials and worksheets for use in their observed lessons[15]. These lessons were designed from either local newspapers, from materials in their environment, or from current topical issues, such as elections. It is possibly not coincidental that Sam, Cedric and Delia were in schools where photocopying facilities were readily available. Other teachers tended to rely on ideas derived from illustrative learning programmes, textbooks, INSET notes, conference notes etc. While these are appropriate activities the new roles for educators expect teachers to become designers of learning programmes.

There was some evidence of teachers performing the third role of apprenticing learners into ways of investigating mathematics. For example, in observed lessons Sam guided learners to derive the rules for the addition of integers, Rosina guided learners to derive formulae from different patterns, and Delia constructed a practical investigation to help learners derive the formula for the volume of a rectangular prism.

[15] This relates to the generic role for educators of 'interpreter, designer of learning programmes and materials' (NDE, 2000). While all teachers clearly adopted the role of 'interpreter' of new curriculum materials, as evidenced by teachers changing meanings and understandings of the new curriculum and by their changing classroom practices discussed in Part 1 and Part 2 above, from the data available it seemed that only a few teachers adopted the role of 'designer of learning programmes and materials' (NDE, 2000).

All teachers were familiar with the fourth role of conveying mathematical conventions and practices to learners prior to their participation in PLESME and this role continues during their participation in PLESME. While PLESME teachers tended to integrate various MLMMS and new generic educator roles some difficulties arose. Teacher difficulties clearly relate to tensions between the Official Projected Identity of the previous performance-based curriculum (still implemented in the FET band) and the Official Projected Identity of Curriculum 2005, as discussed in Chapter 2.

Teachers noted in particular the tension between the new more time-consuming roles (e.g. 'local curriculum developer', 'learning mediator' and relating mathematics to everyday life), and the mathematics schemes of work their districts required them to complete. As explained in Chapter 2 these syllabi (or schemes of work) are generally designed to meet the needs of the FET phase rather than addressing the needs of the new curriculum.

Beatrice and Elaine note a tension in implementing the new curriculum and the time involved:

> Well I would understand it to be that the children first of all have to be active, its very learner centred, and if we teach it you know the OBE way the children do seem to understand. It's very time consuming though. I found now I was working with that last ILP (Illustrative Learning Programme discussed in Chapter 2 above) that you know, that you gave, it took ages to go through that, honestly. I mean the method of teaching is different [Beatrice Interview, November 2000].

> And I think it is a good thing, it's only very time consuming, and I think we need to get used to that… It's a lot of work for the teacher, because of the preparation. Because I think we are still inexperienced so we have to go and look for examples. You know it's not like her I've got something and just get a textbook for it. If you have to go and look for it and study the whole thing it is a lot of preparation. And I don't see where will you get the money for photocopying if you want to have that you know? Because I think that is a problem in the schools… It's not like writing Standard 9 (Grade 11) or so. In Standard 9 you can't implement it, because they (students) don't know what you want. They just look at you and say what do you want. They're not used to that way of teaching you see [Elaine Interview, June 1999].

Other teachers experienced the tension not only in relation to increased time and preparation demands but also as it relates to the implicit tension in simultaneously implementing new curriculum ideas and meeting old curriculum demands. Karl captures this tension in his interviews and questionnaires.

> And I think it's (Curriculum 2005) not as foreign as we all thought it would be it's quite relevant I think. It's (participation in PLESME) opening my eyes basically to other ways of doing things. You tend to be very narrow-minded looking at things in your maths class or when you do things by yourself, but when you come and discuss it, and speak to people and get these other ideas you see that it can be interesting and it can be different. You can make a change. Your way is not the only way. So it's enlightening me it really does.
>
> The other thing about the workshops now it's hard to implement it straight away with the new knowledge that I have. I find it difficult to go back to my classroom. When I do it, it is an extra that I am doing. It's not implemented in the class yet. We are not working according to this so there is a type of conflict with myself now. How do I get to do it? But I want to do it and I also can't do it because I have to prepare these pupils for another type of situation and it becomes a bit frustrating, because they wouldn't be examined in this fashion right now. They are going to write matric now and it is still going to be content based. The change is coming too slow, and its not coming too slow, we need to learn right. I'm contradicting myself (laughs).
>
> What I am basically saying for me I want it now to be different and I can do this now in my class but at the same time I can't because I have to prepare them for some other situation. I hope I am making myself clear. Because I have got the Standard Sevens and Eights (Grade 9 and 10) and I know they are going to write a matric exam the same like the previous time, its not going to change, there are no major changes that I've seen really taking place. That is a bit frustrating. I do implement but as extra or enrichment if I see they don't understand something clearly then I will try to do it this way, like projects and things like that and hopefully they will understand things better. But a lot of the time I have noticed when you try to teach children to understand things and you ask things in the exams they still content orientated. They just want to give you the answers rather than explaining why. The ones about those patterns I have found quite helpful. I've tried to teach it that way, its something I've discovered, the algebra, I have got them to

identify patterns. And it *nogal* (Afrikaans word meaning moreover) helps with quite a number of them…

I'm basically at the stages now where I am internally changing things for myself and see how I can implement it, (inaudible). I'm trying to compare the two (older and newer methods) and see where I can fit in now with the way things are going and where can I implement the things I have learnt from the course. So I'm basically just reflecting on what I have learnt and then compare it with the current situation. And where I can if I can see pupils that didn't understand, who were very frustrated with algebra, then I tried it with the patterns and explained to them look it is not that difficult. So started with the patterns that had the numbers and then developed an algebraic equation from that…It will take a lot of work if the pupils had started earlier it would work better because a lot of them are totally disillusioned with maths and they're basically thinking 'I'm going to leave maths.'… The motivation is a big problem. How do we motivate them to do maths? … They do enjoy it, that's what I've noticed. They really do enjoy it, these other ideas and the games that you play with them. But it's always seen as going back to the work again (laughs). So they basically see it as divorced from the actual maths and then that type of maths [Karl Interview, June 1999].

From this quote we can see that while Karl demonstrates some support and ownership of the new curriculum ideas and outcomes (see the first five sentences before the 'but'), he struggles with the implicit tensions involved between the two curricula (the outgoing performance based and the newly implemented competence based Curriculum 2005) existing in his school simultaneously. Karl also explains that there are difficulties in changing learners' perceptions towards mathematics and even though they enjoy the newer methods they do not see these as 'real' mathematics. Similarly in July 2000 Karl expressed various tensions relating to the implementation of new curriculum ideas in written form:

At times I find myself *trapped between the old and the new* which makes teaching and learning in my class suffer: I find that my ideas of teaching and learning has changed but that the syllabus is at times "too much" for the new practices that will finally see those ideas become a reality in the classroom situation; Dictations from the Department of Education with regards to the

> syllabus and classroom practices conflicts with some of the new ideas; one then becomes frustrated and tends to fall back into the old ways just to be able to cope with all the demands [Karl Questionnaire, July 2000].

Clearly teachers experienced the predicted tensions (discussed in Chapter 2) in implementing MLMMS and Curriculum 2005, namely: the time difficulties, increased demands on teachers, watering down of mathematical content, and the tensions between the co-existence of the incoming and outgoing curricula.

Many teachers reconciled these tensions by finding a balance between the incoming Curriculum 2005 and the outgoing (but still implemented at FET level) performance-based curriculum. Teachers found a balance between the methodological roles of 'learning mediator' versus 'conveyor of knowledge' and the mathematical roles of 'assisting learners to become appliers of mathematics in their everyday life' and 'conveying mathematical theorems, conventions and algorithms' (essential for success at the current FET phase). For example Sam, in discussing his newfound confidence, explained:

> And things like when you have your syllabus your HOD will tell me I have to cover everything and then just to please him I must cover everything but now I'm to a point where I can say listen there's no need for me to cover everything I've got the confidence and I say listen this is my time what I have, this is what's important this topic follows through right up to Grade 12 so this is what I'm going to do in this case and now when I walk into my classroom and I go on with my learners so I know *I've got a goal for Grade 12 and I've got my OBE's outcomes which I use as well so I know how to strike that balance between the two for now in the interim until our Grade 12 exam falls away* [Sam Interview, November 2000].

The quotes above indicate a critical stance towards curriculum implementation by Karl, Beatrice[16], Elaine and Sam. That is not to say that they did not support curriculum change. Indeed interviews show a strong resonance with the political and philosophical aims of the curriculum, but this resonance is not uncritical and interviews indicate an ability on the part of the teachers to express the tensions involved

[16] At the AMESA 1999 conference Beatrice presented a paper in which she critiqued the Mathematics Grade 7 Illustrative Learning Programmes provided to schools by the Gauteng Department of Education. She primarily criticized them for having too little (watered down) mathematics and for being extremely time-consuming.

in curriculum implementation. Karl, Elaine and Sam are secondary school teachers, and therefore the tension between the co-existence of the competence based Curriculum 2005 at Grade 8 and 9 and the unchanged Grades 10, 11 and 12 FET band in their schools demands that they work simultaneously with both systems.

From the above we see that while teachers adopted roles in their classroom practices involving: 'assisting learners to apply mathematics to everyday contexts' and 'conveying mathematical norms, conventions and algorithms to learners', there were differences between teachers in the manner and the extent to which they adopted the roles of preparing learners for critical, democratic citizenship; designing their own learning programmes and materials; apprenticing learners into ways of investigating mathematics and adopting a critical stance towards curriculum implementation.

Since the number of lesson observations per teacher was limited and the sample of teachers in this study is small, it is difficult to locate a specific factor that influenced the take-up. It does, however, seem likely that teachers' mathematical histories, interests and understanding influenced the take-up of mathematical roles while the adoption of a more critical stance to curriculum implementation seemed to be influenced by the difficulties and tensions that teachers experienced in implementation of new curriculum ideas. These difficulties were particularly striking for high school teachers since they often taught across the GET band and the FET band.

2.2 Changing Practices in relation to increased participation in (Mathematics) Education more broadly

2.2.1 Changing forms of participation in the practice of discussions on education

All teachers explained how their participation in *discussions* relating to the new curriculum and mathematics education with fellow educators at schools and in their local communities had increased during the two-year period.

> *I now speak more freely about OBE*[17] *to my principal; I might just add that the conversation is normally initiated by him. My colleagues also tend to listen more to me than before, when I am talking OBE or anything else for that matter. I speak more freely to anybody willing to listen about OBE* because the programme has empowered me with regards to OBE and I have therefore the confidence to do so… As with OBE I speak to anybody that is willing to listen to my ideas and frustrations about math Education… [Karl Questionnaire, July 2000].
>
> *If someone questions me, I can answer them and give them a good argument* based on my pool of people I work with [Sam Questionnaire, July 2000].
>
> I have more confidence in talking about OBE. I try to show the teachers the advantage of OBE. I try to show them that teaching can be fun and that learners can enjoy it. I have learnt to express myself to adults. *I have learnt that I can talk in front of adults. I have learnt to try and help teachers with problems with OBE* [Elaine Questionnaire, July 2000].

The quotes above are not only illustrative of changing practices but also illustrate a close relationship between these practices and the forms of participation and alignment with related communities. They show shifting relations between teachers and the *communities* in which their participation increases (see italicised parts in the excerpts above) and new perceptions by others of them (i.e. new status). For example, Karl explains how his principal and others now listen to him and actively seek out his opinion, Sam explains how his ability to justify his arguments is linked to the support of the community of people he works with (in this case the PLESME community of practice), and Elaine talks about having developed confidence to talk about 'OBE' with adults, especially teachers.

Teachers also became more involved in discussions about mathematics education through their participation in conferences of the national mathematics education association (AMESA):

> Initially I was anxious because it was my first time attending an AMESA conference. It was a great meeting, so many maths teachers sharing ideas…I use my AMESA booklet with the

[17] It should be noted that in South Africa it became common to refer to the whole new curriculum package as OBE. This confusion was discussed in Chapter 2, but it is important to read this in its most broad sense.

> teacher presentations as a useful tool in my classroom…The teachers on the PLESME programme finally had an opportunity to bond and develop strong personal relationships with one another [Delia Questionnaire, July 2000].
>
> The conference created a platform for me to rub shoulders with more experienced educators. To suck more knowledge from them. When I was presenting my 'how I teach it', I knew that I was listened by other educators who will in return criticize me more constructively [Moses Questionnaire, July 2000].
>
> The AMESA conference was excellent especially as a presenter who had to show people how I present a lesson to my learners. I was too impressed because they gave me more ideas on how I can make the lesson more interesting [Rosina Questionnaire, July 2000].
>
> AMESA has been an eye opener for me since it was my first time attending such a conference. AMESA has its own "academic culture" which at times seems to exclude the "ordinary teacher" from the club. There is however a strong tendency to accommodate a "bigger" attendance by presenting a greater variety of programmes, presentations, workshops and so on. A type of something for everyone approach, which is good…I was quite impressed about what and how much there is to learn, and that there is in fact an organization like AMESA that is researching and influencing the changes in our education system in this country [Karl Questionnaire, July 2000].

The quotes above indicate an immersion into activities that are part of the profession of being a mathematics educator. That is in the above cases talking with confidence about mathematics education and about curriculum change with colleagues in schools and in professional associations. All teachers indicated alignment with the AMESA community although Karl notes some difficulty with "the academic culture" that sometimes excludes ordinary teachers. This comment highlights Karl's identity of himself as an 'ordinary teacher' although in 2002 Karl registered for studies in a Bachelor of Science in Mathematics Education indicating his interest in the 'academic culture' he experienced at AMESA.

The changing participation in, and alignment to, various communities is discussed in more detail in Part 4 of this chapter, but it is important that the close interrelationship between these two components is noted here.

2.2.2 Changing forms of participation in a range of school activities

In the same way as teacher participation in discussions in education had increased, there were indications that teachers' involvement in *general school activities* (including participating in various committees) had increased. This was both a product of teachers' confidence and willingness to input their ideas in various forums as well as them being invited and expected by people to share their ideas. Nine of the ten teachers[18] gave a wide range of anecdotal evidence of their increased participation in various activities (other than in informal discussions). These activities included running workshops, taking more responsibility within the mathematics department in the school, representing their school in department management workshops, organising school functions, sitting on committees and so forth. The following quotes capture this increasing involvement:

> My new-found confidence as a teacher has led me to become more involved in the organisation of the school. New committees that I now also serve on is our school SGB, the assessment committee and the soon to be school development team. The above can be directly linked to PLESME having had a confidence building effect on my teaching profession. I also tend to give more input into our subject meetings. It has been the first time that I have presented at a conference not even to mention giving a presentation [Karl Questionnaire, July 2000].

> I prep all the Grade 9's work, setting tests, exams, worksheets… They (mathematics colleagues) ask me to check or draw up the projects of the Grade 8 and 9. Application questions that is my field. Management wants me to teach Grade 10 next year [Sam Questionnaire, July 2000].

[18] For Rosina, such anecdotal evidence is absent. While Rosina's participation in terms of discussions with various people (e.g. with teachers in her community, with the women's group that she is actively involved in, with teachers at AMESA, with her principal and district officials) increases she does not provide evidence of increased participation in other activities or committees. This is not to say that she was not involved in these but rather that she did not volunteer such anecdotes during interviews, informal discussions or in questionnaires. Rosina did however actively participate in the organisation of two workshops that PLESME teachers ran for the launch of the SOWELDO branch of AMESA. In this launch she took an active role in inviting teachers from neighbouring schools in Soweto.

> During the past year I have been involved in school fund raising efforts. I have served on the finance committee…and on the functions committee [Delia Questionnaire, July 2000].

> Accolades given to serve as extrinsic motivation – nomination for Teachers' teacher of the year, nomination for assessment lesson for GDE officials and television production, nomination as SGB deputy chairperson – all possible due to innovative approach in education brought about by PLESME inspiration and vigour [Cedric Questionnaire, July 2000].

> The general school organisational activities has been that my colleagues look at me as someone who is currently having a better knowledge in terms of subject organisation not only in mathematics but also in other subjects that have bearing in mathematics and are mathematics related….I was in a position to help when I was required to, to impart my understanding and knowledge in other school activities [Moses Questionnaire, July 2000].

All teachers were increasingly becoming 'leaders' in their communities in the field of mathematics education and the new Curriculum in general. In this new role teachers are required to 'participate in school decision making structures' and will perform these 'in ways which are democratic, which support learners and colleagues, and which demonstrate responsiveness to changing circumstances and needs' (NDE, 2000, p.13). This was evidenced by teachers increased participation in the range of practices as evidenced by the quotes above. The development of 'leader educators' was indeed a strong focus of the INSET (see Chapter 3). The adoption of 'leader' roles also relates to the adoption of the NDE's 'community, citizenship and pastoral role' in the sense that teachers did 'develop supportive relations with parents and other key persons and organisations' (NDE, 2000, p.14).

The first quote by Karl (above) captures the close link between increased participation in activities and his developing confidence. The last two quotes by Cedric and Moses illustrate the interrelationship between increased participation in various activities and their changing status/identity in their schools. Cedric notes that he is receiving accolades such as the nomination for 'teacher of the year' and Moses notes that his colleagues now look at him as someone who has more knowledge in relation to the new curriculum. In this sense teachers' wider participation in activities is both a function of their changing

identity and their changing identity is a function of their increasing participation. In the next section I focus specifically on teachers' changing identities.

2.2.3 Changing roles in relation to the broader professional community

People in the broader community of mathematics education began identifying PLESME teachers as people who had something to offer mathematics education. For example, at the end of 2000 several PLESME teachers were approached by a teacher education organization to apply to work in their organization, and colleagues of mine (at the University and independent education consultants) approached me for the names and telephone numbers of PLESME teachers for participation in research projects, educational media productions and curriculum trialling projects. One teacher was invited to provide a 'plenary response' at the AMESA 2001 conference and another was invited by publishers to work on a textbook. There are numerous other examples I could provide. These examples are indicative of the changing status/identity given to the PLESME teachers by the broader community of mathematics educators.

This changing status also resulted in an increase in teacher participation in professional activities relating to the broader (in the sense of beyond one's own classroom) profession of mathematics education. Teachers participated in the following activities of the profession: providing input into curriculum developments, trialling curriculum materials, attending conferences, presenting at conferences, participating in discussions on current topical issues in mathematics education, developing learning materials, organizing workshops for teachers in their communities and running AMESA mathematics competitions.

This involvement in broader professional activities, and teachers' increased participation in a wide range of school activities as discussed in Part 2.2.2 above, indicates teachers' take-up of the NDE roles for educators of: 'interpreter and designer of learning programmes', 'leader, administrator and manager', 'community citizenship and pastoral role', 'scholar, researcher and lifelong learner' and 'learning area specialist.' The adoption of these roles as evidenced by increased participation in a range of professional activities were both productive of and produced by stronger teacher identities as professional mathematics educators.

Also there was a range of anecdotal evidence of the changing status of teachers (and resulting changing forms of participation) in relation to their district advisors. Discussions between advisors and PLESME teachers became more of a two-way affair. For example Rosina explained:

> I'm more free to talk to the DVCs (district advisors) than before because if I can argue a thing with them so that we can be able to come to an agreement, we never did that. We were afraid of these people [Rosina Interview, November 2000].

In some cases advisors would approach PLESME teachers for information and support materials on the new mathematics curriculum. For example, Elaine noted:

> Even my what do you call it DC (district advisor) comes to ask me nowadays what do I think about this whole thing (the new curriculum) [Elaine Interview, November 2000].

Many teachers developed the confidence to take a more critical stance towards the way in which Curriculum 2005 was being implemented (discussed further in part 5). For example, Karl explained how he challenged a Department of Education person who ran a workshop on the development of OBE materials and argued that if the Department truly wanted teacher input (rather than simply calling them to a meeting as a token to indicate consultation) then they should be prepared to listen to his opinion. Taking a critical stance towards the way in which curriculum change was being implemented Karl wrote:

> Dictations from the Department of Education with regards to the syllabus and classroom practices conflicts with some of the new ideas… [Karl Questionnaire, July 2000].

In Summary:

In this part of the chapter I have provided evidence of the way in which the changing practices and roles of teachers assisted in the development of stronger identities as professionals, as mathematics teachers and as educators. I provided a wide range of evidence to illustrate the way in which teachers

had indeed *become* ‘professional (mathematics) educators’ not only in relation to participating in a wide range of practices related to the profession but also in relation to the way in which they were identified as ‘professional (mathematics) educators’ by the broader professional community, including teachers, principals, publishers, district advisors, consultants, teacher development organizations, professional associations, learners, parents, and university lecturers.

I also provided vignettes of two teachers’ lessons in order to illustrate the way in which teachers’ mathematical histories play a part in affecting their mathematical trajectories and hence the nature of the implementation of new curriculum ideas in mathematics teaching. In this respect while all teachers moved towards mastery of the ‘new’ practice of mathematics teaching, some teachers faced more challenges than others in relation to integrating deeper mathematical understanding with new forms of practice (such as learner centred practices).

The study now turns, in Part 3, to a focus on the differential development of teachers’ *mathematical* identities within their broader identities as ‘professional mathematics educators.’

Part 3: Teacher learning as evolving (mathematical) identities

When analysing teacher questionnaires, interviews and journal entries it was clear that teachers described their learning in terms of becoming someone different. Learning was indeed about changing identity as is most clearly illustrated in the following interaction.

> You know before I always used to introduce myself as the music teacher, now I introduce myself as the maths teacher [Beatrice Interview, July 1999].

Later in an interview Beatrice further explained this changing identity:

> When I came in here I filled up the music post. Then I was the music teacher, I taught music, so that is how I have been known, I teach after hours, so I'm called the music teacher but it seems to have changed you know that I'm the music teacher and all of a sudden because I also enjoy the maths, you see I didn't ask to do the maths when our maths teacher left she asked that I do the maths…and somehow she went to the principal and asked… And Maths you must remember Mellony was my favourite subject at school. It's just that at that stage there were no musicians and I thought that that would be my, so that's how come I chose but I love maths all my life and I like teaching it also. But I am now called the maths teacher, because all everyone comes to me even the little ones, the lower teachers they will come and ask me you know how do you do this, how do you teach that instead of music [Beatrice Interview, November 2000].

The teachers were developing identities as professional, confident and competent *mathematics* teachers. The changes in teacher identities tended to cohere with their school communities' perceptions of them as 'expert' *mathematics* teachers and as knowledgeable educators with a lot to offer education in general (discussed in part 2b above). Teachers gave a lot of anecdotal evidence of how their status, as linked to their increasing responsibilities and changing identities, in their school communities had changed over the past two years. This is also clearly evidenced in Ivan's vignette and in the quotes given in Part 2.2 relating to teachers changing practices. Sam sums this up:

> I must say you get your status as well in your community, it's one of the good things, even with your children, your children see you as for example the other classes I don't teach, the children say Mr (Sam) will you teach us next year for maths please? [Sam Interview, June 2000].

Teacher identities had changed in relation to:

- Their changing practices and roles (or forms of participation) in relation to classroom practices (discussed above).
- Their changing practices and roles (or forms of participation) in relation to the broader professional community (discussed above).
- Their development of Mathematical identities (discussed below).

Changing practices involve the adoption of new roles that in turn lead to the development of new identities. As Wenger (1998) explained, it is possible to design roles for teachers but it is not possible to design the identities of teachers that form in uneven ways. One of the seven generic roles for educators is being a 'subject specialist' (NDE, 2000). In this part of the chapter I focus on the development of teacher identities in relation to becoming mathematics specialists and developing mathematical confidence.

As explained in the previous section, the take-up of this role by teachers was different depending on teachers' mathematical histories and their mathematical trajectories. This is illustrated in relation to teaching practice in the vignettes of Rosina and Delia in Part 2. In this section I wish to focus on the uneven development of teachers' mathematical identities in relation to teachers development of an interest in studying mathematics further, the development of a mathematical gaze and their prioritisation of mathematics learning within the more general learning that occurred through participation in PLESME.

I begin with a narrative vignette of Sam that illustrates the process of the development of a stronger mathematical identity over the two-and-a-half year period. Thereafter I discuss the development of mathematical identities for the sample of teachers in relation to three main sources of evidence.

This part is therefore structured as follows:

3.1 The development of mathematical identities: a vignette of Sam.
3.2 The imagination to study Mathematics Education further.
3.3 The development of a mathematical gaze.
3.4 A focus on mathematics learning.

3.1 The development of mathematical identities: a vignette of Sam

From Part 2 it is clear that for all teachers there is some evidence of developing new identities in relation to: themselves as educators; the ways in which people in various communities 'identified' them, and in the roles they took up in their mathematics classroom. That is all teachers developed identities as 'more[19]' confident and competent educators in relation to new curriculum philosophies and practices. However, as we have seen above, differences emerged in relation to the adoption of 'mathematics-specific' roles and the development of mathematical identities.

Differences were evident in the development of teacher identities in the extent to which *mathematics per se* was foregrounded in teachers' ways of talking about their changing practices and in their explanations of their changing 'ways of being.' In this section I focus on the development of stronger *mathematical* identities, within the development of stronger identities as competent and confident educators.

I focus on this aspect not only because the development of mathematical identities differed between teachers but also because the focus of this study is on *mathematics* teacher learning and it is therefore important to examine teachers' *mathematical* 'becomings'.

The vignette of Sam illustrates with some richness the nature of the *development* of stronger mathematical identities. I have chosen Sam because of his focus on mathematics and mathematical learning throughout the study.

[19] I put this 'more' in to acknowledge that confidence and competence are relative and dynamic.

A vignette of Sam

At the start of PLESME in January 1999 Sam taught primarily Accountancy and Business Economics at a high school in Eldorado Park. Sam had taught Mathematics to Grade 8 and 9 students in previous years but due to redeployments of teachers at his school he was forced leave his mathematics classes to 'fill the gaps'. He negotiated with his school to teach one mathematics class so that he could participate in PLESME. Sam expressed that his intention was to remain in teaching for approximately five years and then move into a career in computers. Sam had taught Mathematics for three years. In July 1999 Sam moved to another school where he taught Grade 8 and 9 Mathematics.

At the start of PLESME in January 1999 Sam struggled to make mathematical sense of various new specific outcomes. For example:

> With number 4, critically analyse how maths relationships are used – that would be important for one of the outcomes, for instance specifics will come in here, where you can analyse specifics in certain diagrams and so on… As regards cultural products and so on you need mathematical things, shape, space and time…Space and time? Nothing comes to mind. It is too broad [Sam Interview, January 1999].

At the end of PLESME Sam indicated both an enthusiasm and a strong ability to explain, with the use of examples from his classroom teaching, the mathematical meaning of various new specific outcomes. Especially interesting in Sam's response to these outcomes two years later is the evidence of the development of a strong *mathematical gaze* on the world. This mathematical gaze emerged both in terms of finding ideas for mathematics teaching and as a critical mathematics gaze for approaching various aspects of his life such as checking the tax on pay-slips and comparing prices of different size packages in a supermarket. The following abbreviated extract[20] indicates the development of Sam's mathematical gaze (with a critical stance) and of an identity as a person with mathematical expertise:

[20] For the full excerpt see page 217.

Okay this is one (referring to SO4) I use quite a lot. It's where for example in our NUE book one of the teachers came to me and said 'listen they paid me wrong'… So she asked me now how much money. *I said 'okay this is the formula from the NUE book so lets see how much she has been paid' and we went through that… and we sent a letter through… and the same with our increases they came to me and asked me how so so and so… And so when I get my pay-slip and I work out my money the taxes everything is fine so I have the skill and the knowledge that they paid me correct*… Cricket as well if you look at your cricket scores… *Your bleach is normally 750ml now it gets to 1l and that changes your value…*
MG: OK so you think about that when you are buying the stuff?
Sam: Ya
MG: Okay, in your teaching, what does this outcome mean for your learners?
Sam: Like the cell phone project we went through it and they've seen what happened when you collect your data in order to make an informed judgement… With my surface area and volume when they wrapped their presents… if my class was a storeroom for the boxes how will they fit etcetera… Even some of the taxi drivers I have seen them use a graph pasted on dashboard
MG: Specific Outcome number eight says 'analyse natural forms cultural products and processes as representations of shape space and time'. Some of what you have said already links to that. Anything else?
Sam: For example with your coke cans one question I've asked is they had to calculate the volume of the coke can as a cylinder with a circular base and another one with the square base and to see that both can have the same volume but the question is why am I using the coke can with the circular base? Why don't I swap the two and the one said it would have sharp edges it would be uncomfortable… Yaa if you look at our rugby, …the rugby scores how they've changed and how that influences us [Sam Interview, November 2000].

The above excerpt provides evidence to show that Sam clearly became a more confident 'mathematical thinker' who observed the world through a mathematical lens and found ideas to use in his mathematics teaching. The development of original mathematics lessons derived from current topical issues in Sam's environment (as evidenced in the interview above) began early in PLESME. In the interview in June 1999 Sam explained his understanding of the mathematics that underpins the South African election system and explained that he wanted to develop this for his teaching:

What does it mean by saying a party must get two-thirds majority[21]. Many people said you must get 67% but that is not two-thirds. Also you can't have half a seat in parliament. So that is how mathematics is important… In the holidays I want to draw the learning areas together. I want to take a topic like 'Elections 99' and work with other teachers to develop this and present it to my Head of Department. I can do this because I know the outcomes from your course [Sam Interview, June 1999].

[21] At the time of the elections the press speculated widely on whether the ANC would receive two-thirds of the votes, which would allow it to change the constitution. The question that arose was where did 2/3 get rounded off (i.e. to 66,66667? or 66,7? or 67%)

The final sentence illustrates Sam's confidence in his ability to do this and he links this ability to having knowledge of the new curriculum. Furthermore there is evidence that Sam developed an ability to use mathematical skills in order to critically analyse aspects of his environment:

In order for me to question and change something I need to know it. If I don't know it on a maths level I can't change it. Maybe that is why banks have lowered their interest rates now because someone questioned the interest…If a machine malfunctions and gives a different answer you say listen, this is what I did and I did it this way and you are wrong and I am right. If a calculator says 1 + 3 = 5 because of his previous knowledge he will say it can't be 5 the calculator is incorrect. The same with questioning computers, without these logical processes and being able to justify and research you can't (question computers) [Sam Interview, June 1999].

During the two-year period Sam's identity as a competent '*mathematics* teacher' also strengthened. In the interview in June 1999 Sam indicated that he had developed a strong identity as a mathematics teacher. He explained that one of the things he was best at was mathematics and that it was one of his goals to be the 'best teacher':

I'm a maths teacher. I can work at a fast pace. Instead of falling asleep, I'm busy and active, I calculate, I do what I do best, its maths…It (participation in PLESME) makes me feel more secure in my job, where I can how can I say, it's equipping me for OBE Education and so on and redeployments. I won't be the first on the list (the redeployment list). Because if I am first on the list I can always go up to the GDE and try and train some teachers and Yaah. I get satisfaction out of this. To me I'm at the forefront of the change. It's one of my goals to be the best teacher, not just to get a salary [Sam Interview, June 1999].

The above quote not only indicates Sam's strengthened identity as a mathematics teacher but as someone who identifies himself as a leader in the field of curriculum implementation and change. This is clear when Sam says, 'I can always go up to the GDE and try and train some teachers… I'm at the forefront of the change.' Similarly in July 2000 Sam provides evidence of his strengthened identity as a confident and competent mathematics teacher who is ready to lead others in curriculum change:

I am ten times better and more confident than what I was two years ago. I enjoy my 'maths' teaching so much I will probably do it for a long time to come. I want to study and get my degree in Maths Education…I want to stay in the classroom…Because of PLESME I have options and I come to school with an even bigger smile… My mathematical sense has deepened. I can do lectures. I can conduct workshops. I think *I am ready to work in Eldo's to help my fellow teachers* to

see what I have seen in maths education and maybe experience what I have experienced. I will present at this conference every year and will attend it every year [Sam Questionnaire, July 2000].

The excerpts above indicate the projection of Sam's identity as a mathematics teacher that is beyond present time. They indicate a clear mathematical trajectory that prioritises mathematics learning in the present and the future. This is especially interesting in relation to Sam's earlier point that he did not see teaching as a long-term career, he feared redeployment and had planned to move into a field involving computers. Sam noted:

Yeah because my main ideas when I started teaching five years ago I said I'm just going to teach for five years and that is it. And then I am going to go into my computers, because I'm coming to the end of my five years and I still want to do it. The computers are a hobby now [Sam Interview, November 2000].

Clearly, at the start of PLESME Sam did not identify strongly with the profession of mathematics teaching or teaching. The quote above illustrates that over the two years Sam extended his identity as a 'temporary mathematics teacher' to that of a professional mathematics teacher. Sam had developed a mathematical learning trajectory that extended beyond the past and the present into the future. Furthermore Sam's 'imagination[22]' (i.e. his projection of 'belonging' in mathematics education 'in the future') shows interest in the 'leader teacher' role as encompassed in the generic roles for educators and in the aims of PLESME. Sam expressed this through his enthusiasm to work with other mathematics teachers, run workshops and present at conferences.

Towards the end of 2000 others working in the field of teacher development noted Sam's strengthened identity as a professional mathematics teacher with the required qualities for working with other teachers. As explained in Part 4 of Chapter 5, Sam was approached by an INSET organization to apply for a position that involved working with mathematics teachers in various provinces in the country. Sam had to weigh up the extent to which his mathematical identity was more aligned to teaching mathematics to learners or working as a 'leader educator' with mathematics teachers. In the end, Sam

[22] According to Wenger (1998) identity involves 'belonging' to a community of practice. A central mode of belonging is 'imagination'. Imagination involves 'creating images of the world and seeing connections through time and space by extrapolating from one's own experience' (p.173).

chose to remain in teaching, register[23] for the Bachelor of Science Honours in Mathematics Teaching degree and to postpone becoming a 'mathematics teacher educator' for later.

What is important to note is that in relation to both Sam's imagination of his immediate future (i.e. to stay in mathematics teaching and study mathematics further) and his longer-term future (i.e. to become a mathematics teacher educator), mathematics is foregrounded. Sam has abandoned his trajectory and imagination into computers or other careers outside of the profession of mathematics education.

Sam's story illustrates the development of a strong identity as a 'professional *mathematics* teacher' with a trajectory that incorporates further studies in mathematics and working as a mathematics teacher educator in the future. It is important that Sam's story be located in the context of the broader sample of teachers from which he was chosen. I now examine this broader sample of teachers.

While all teachers developed stronger identities as mathematics teachers there were varying degrees in the development of *mathematical* trajectories relating to these identities. As in Sam's story, teachers' strengthened mathematical identities were evidenced by three main sources:

- The imagination to study Mathematics Education further.
- The development of a mathematical gaze.
- A focus on mathematics learning.

The above sources of evidence are grounded in the data and form the analytic framework for analysing and describing teachers' changing mathematical trajectories. Recall that as trajectories, identities incorporate the past and future while negotiating the present (Wenger, 1998). I deal with each of these sources of evidence separately.

[23] In 2001 Sam completed the first year of the B Sc Honours in Mathematics Education degree. In 2002 Sam continued with this degree and encouraged his colleague Karl to register in January 2002.

3.2 Teachers' expressed interest (and/or intention) to study mathematics further

Several teachers 'imagined' a path in which they continued to specialise in *mathematics*. More than half of the teachers namely, Sam, Beatrice, Rosina[24], Ivan, Puleng, Moses and Karl expressed interest in studying *mathematics* (or mathematics education) further and in so doing projected their strengthened mathematical identities into the future. For example Beatrice wrote:

> I am thinking of doing a Maths course later to extend my mathematical knowledge even further [Beatrice Questionnaire, November 1999].

Later, in the same questionnaire, Beatrice wrote:

> They (people at RADMASTE and AMESA whom she visited during a PLESME fieldtrip) made me feel like a Master of Maths – I'm not too old to become one – What do you think Mel? [Beatrice Questionnaire, November 1999].

In 2001 Puleng registered for a Further Diploma in Mathematics Education, Sam registered for a Bachelor of Science Honors degree in Mathematics Education and Rosina registered for a Higher Diploma in Education. In January 2002 Karl began his studies for a Bachelor of Science Honours degree in Mathematics Education.

The expressed interest of teachers in studying mathematics further indicates that these teachers were developing stronger identities as *mathematics* teachers, and indicates the 'imagination' of these identities into the future. Although other teachers provided evidence to show that they viewed learning as a life long process (discussed in Part 5), *mathematics* was not necessarily pronounced in this ongoing learning process.

3.3 The development of a mathematical gaze

For three of the ten teachers, namely Delia, Sam and Elaine, there was clear evidence of the development of a stronger mathematical gaze on the world. For all three teachers this mathematical gaze emerged throughout the data (interviews, questionnaires, field-notes and classroom observations). These mathematical gazes were, in addition, tailored to the purposes of teaching. These teachers gave evidence of both the way in which they saw aspects of their everyday world through a mathematical lens *and* the way in which they designed 'original' lessons based on their mathematical view of the world around them. The following quotes illustrate the development of this mathematical gaze and the exploitation of this gaze for teaching purposes:

> I have a parrot. If you look at its feather it is symmetry in the middle, colour and by counting. It was interesting. I didn't know it. One day I was pulling out the feathers, in the holiday, I was bored, so I checked. I was amazed. I thought I must use this when I start symmetry… The whole approach has changed. Presentation and my whole understanding of learning maths, I would have enjoyed it more had I learned like this. For myself, if I open a newspaper I think what can I use in my class, or think this is another way of drawing a graph. I saw one (a graph in a newspaper) that started at seventeen. Like the example we (PLESME group in a workshop) did on holiday, I start to realise how much they (advertisements) are bluffing you. I use it (mathematics) in everyday life, like you told us to look for the per gram price in shops… It can be enjoyable, before I wouldn't look at birds' feathers twice. I looked for a sequence. I'm looking for maths in the environment and even look at flowers, floors etcetera [Elaine Interview, June 1999].

> To introduce a new section, I normally look around me to see what I can use instead of the textbooks introduction, e.g. to teach ratio, I realised I could use the 24 biscuit and 48 biscuit Wheetbix boxes [Delia Questionnaire, July 2000].

[24] Rosina's interest in studying mathematics teaching further was linked to her realization that studies in mathematics teaching did not necessarily have to involve high-level mathematics. In an interview in June 1999 Rosina explained: 'we are panicking afraid to go further with our studies and yet things can be easy if we do them practically [Rosina Interview, June 1999].

I think of Barry[25] with all his stuff in his class (laughs), and that helps me hey, because I did a nice lesson with Wheatbix boxes. I got the children to bring '48' and '24' Wheatbix boxes and in the lesson I did percentages, rate, ratio, what else, using the boxes I had. All that I said to them is 'your mother buys (Wheatbix), only two of you out of a family of six eat Wheatbix. Your brother eats two, your sister eats one, so that's a ratio of two to one. So there are 48 biscuits in a box, how many meals, breakfasts, will it provide. You know your mother can't just go to the shop and take six boxes off the shelf she must have an idea if she is going to do the monthly groceries. So how many boxes do you think she must buy?' And then we did it with three children in the family. I first did it with two, you know one is to two, and then I can't remember the other ratio but it was with three children. And then I said 'what percentage of the family eats the Wheatbix? And, what was the rate for one Wheatbix?' because you know the price was on the box, and, then I said 'Okay how much did John eat and how much did that cost?'. Things like that and we had so much fun. Then I took a Nutrafix box and I said 'who likes Nutrafix?' Who likes Wheatbix? Why?' 'Because it doesn't taste nice'. And we went into the nutritional value and we compared the two and we said yes we do have choices and how do you choose. Some choose because they like the taste, others choose because they like more protein, more fibre etcetera. And the children thoroughly enjoyed it… And I did it with the one class where they gave me some questions… And that was a very good introduction to ratio, percentage and rate [Delia Interview, November 2000].

There is no more 'this is it' and 'you must just learn it'. In order for me to question and change something I need to know. If I don't know it on a maths level I can't question it. Maybe that's why banks have lower interest rates because someone questioned the interest… In the holidays I want to draw learning areas together. Take a topic, elections 99, and work with other teachers to develop this… [Sam Interview, June 1999]

The mathematical gazes developed by the teachers above were supported by their mathematical histories that they brought with them. The mathematical histories for these three teachers involved

[25] Barry is a PLESME teacher who ran a workshop with PLESME colleagues in his class. In this workshop he shared with us a wide range of teaching resources he had collected over his thirty- years as a mathematics teacher. Many of his resources were made form discarded items such as toilet roles, boxes etc. Barry was not included in the sample of teachers since his pending retirement prevented him from participating in the final stages of the research.

successful experiences of studying and enjoying mathematics. As Table 7.1 shows, Sam, Delia and Elaine all successfully completed Grade 12 Mathematics and furthermore studied mathematics in their undergraduate teaching studies. All three teachers studied mathematics teaching at high school level and therefore the mathematics in their studies was of a higher level than the primary teachers in PLESME. Furthermore Sam achieved a distinction for Mathematics in his teaching Diploma, Delia studied Mathematics-1 at university level (the only teacher in the sample to have university level mathematics) and Elaine studied a Further Diploma in Education specialising in mathematics.

These positive experiences of mathematics education provided teachers with a mathematical confidence, competence and interest in engaging with mathematics during PLESME workshops, while observing the world around them and in teaching mathematics. These histories therefore guided teachers' mathematical trajectories in a way that influenced their learning during PLESME and their learning into the future.

3.4 A focus on mathematics learning

In the questionnaires of November 1999 and July 2000 teachers were asked to list what they felt were the main benefits of participating in PLESME. The extent to which mathematics was sometimes absent in several teachers' responses is interesting. For example in Karl's list of benefits in July 2000 he wrote:

- Building self-confidence as a teacher.
- Being informed about the latest developments in the profession.
- Being part of a group of teachers exposes one to different interpretations and practices of certain aspects of the profession which can be very inspirational and informative.
- The accreditation and the fact that we got a certificate made the long hours, that at times seemed too long, more tolerable.
- The honorariums we received for our schools were needed and welcomed – It helped keep me motivated.
- In PLESME my opinion counts! [Karl Questionnaire, July 2000].

While most PLESME workshops dealt with mathematical content in relation to pedagogical issues (for example: language issues in the maths classroom; mathematics and learner-centred practices; assessment and mathematics etc.) approximately a fifth of the workshops dealt with mathematical content *per se*. The absence of the word 'mathematics' in teacher responses is therefore interesting.

For four of the teachers, namely Karl, Rosina, Puleng and Cedric, the term 'mathematics' or 'maths' did not feature in their responses to what they saw as the major benefits of participating in PLESME. For these teachers mathematics was 'backgrounded' to other aspects of their learning such as 'building self confidence as a teacher', 'useful information on OBE', 'meeting colleagues', 'being informed about the latest developments in the profession' 'being part of a group of teachers' 'ideas from teachers', 'internal growth' etc. Similarly, mathematics tended to be backgrounded in the questionnaires and interviews of these teachers.

Rosina, Puleng and Cedric trained as primary school teachers and therefore studied little mathematics in their undergraduate studies. This could be one of the influences on whether teachers' backgrounded mathematics in relation to their learning in PLESME. Karl however is a high-school teacher who clearly expressed an interest in studying mathematics further and indeed registered for further mathematics studies. It is therefore difficult to identify the factors that influenced teachers in their foregrounding or backgrounding of mathematics. It is indeed possible that for some teachers 'mathematics' is taken to be implicit in their responses.

For the other teachers in the sample, namely, Sam, Delia, Elaine, Beatrice, Moses and Ivan 'mathematics' was clearly visible in their responses. Mathematics was visible largely in relation to other aspects of learning such as working with other teachers, developing confidence in teaching etc. For example: Delia wrote:

> Meeting teachers from different schools (primary and high schools) who are passionate about teaching *maths*; being able to share ideas and frustrations about teaching *maths* and of the GDE; a very good support system which includes teachers, lecturers, professors etc who have *specialised in maths* [Delia Questionnaire, July 2000].

Similarly Moses wrote:

> The programme outlined and exposed various methods of imparting knowledge to the learners. The programme was thought-provoking because it engaged me to make a research into mathematics education. The fact that the presenters were more knowledgeable, made the whole programme a worthwhile exercise. And that on its own deepened my mathematics insight…It (PLESME) was an eye-opener in so far as how wide my *maths* knowledge is. The programme allowed me to participate with other *mathematics* educators and share relevant matters. It also gave me the courage to impart my *mathematics knowledge* to the learners more boldly [Moses Questionnaire, July 2000].

Thus for these teachers mathematics was emphasised in relation to other aspects of their learning. Beatrice however emphasised the learning of mathematics in its own right:

> I enjoyed it! I have really learnt a lot – *about the subject itself (maths knowledge) and about teaching it* (pedagogical)…I am looking forward to the third phase and developing and running the *Maths dept* at our school. I am thinking of *doing a Maths course* later to *extend my mathematical* knowledge even further [Beatrice Questionnaire, November 1999].

Beatrice similarly focused on her mathematical learning in her interviews:

> I learnt a lot even in content you know there was a lot of things that you people said that I never even knew as a maths teacher. I look at it another way than before because you know I did maths right up until Standard 10 you know but I, but you had to just learn it the way they teach it, but I never really understood it you know…I tell you I understand a lot of things much better now. And I don't think I will forget them either [Beatrice Interview, July 1999].

From the above data there is evidence that for some teachers in the sample mathematics was relatively transparent in relation to their learning and their developing identities as teachers, while for others the importance of mathematics in relation to their learning and their changing identities was foregrounded. Since the sample of teachers is small it is difficult to detect a pattern in the influences on the

development of strong mathematical identities. While it seems clear that all teachers in the sample developed stronger identities as *professional mathematics teachers* it seems that the development of *mathematical* identities in relation to interpreting the world through a mathematical lens was influenced by teachers' mathematical histories.

In Summary

The influence of mathematical histories on the development of present and future mathematical learning and identities needs further exploration. As in the case of the narrative vignettes of Delia and Rosina in Part 2, it seems plausible that stronger mathematical histories (in terms of training and successful experiences) afforded a foregrounding of mathematics in developing teacher identities. Similarly, weaker mathematical histories afforded less prominence to mathematics in relation to developing identities.

It seems plausible that while all teachers developed stronger identities as *professional mathematics teachers*, depending on teachers' mathematical histories, identities differed in relation to where the emphasis was placed in relation to becoming professional, becoming mathematically competent and confident, and becoming teachers capable of implementing new curriculum methodologies. Thus numerous trajectories were available to teachers in relation to their histories and the learning opportunities afforded them through the introduction of a new curriculum and participation in the PLESME practice. All trajectories involved movement towards fuller participation in relation to becoming professional mathematics teachers but several permutations of emphases within identities were available.

The table below summarises the subtle differences that seemed to emerge in the development of teacher identities in the PLESME sample of teachers:

Table 7.3 Different emphases in the development of similar identities

Identity	**Explanation**	**Example**
Professional (mathematics) *teachers*	Mathematical learning is less prominent	Rosina
Professional *mathematics* teachers	Mathematical learning is prominent in its own right	Beatrice
Professional mathematics teachers	Mathematical learning is strongly integrated into both teaching mathematics and the broader activities of the profession	Sam, Delia

I do not wish to argue that the table above represents all possibilities in relation to teacher learning within a mathematics INSET practice. Nor do I wish to imply that each teacher in this study can be easily or clearly placed in one of these identities. Indeed identity is fluid, and therefore in relation to different 'professional mathematics teacher' practices, teachers could foreground different aspects of their learning and their identities. The purpose of the table is merely intended to highlight the need for further exploration in relation to subtle differences in the take-up of developing teacher identities.

Part 4: Teacher learning as evolving alignment and participation in communities

Changing forms of participation in, and alignment to, various communities (school communities, the PLESME community, The AMESA community etc) became increasingly central to teachers' explanations and descriptions of their learning over the two-year period. The increased prevalence of this aspect of teacher learning paralleled the strengthened relationships and networks that developed between teachers and these communities. Various 'communities' were identified from the data and these provide the analytic framework for this part of the chapter. This part will therefore be divided into the following subsections relating to these communities:

4.1 The PLESME community (the teachers, presenters and myself as co-ordinator).
4.2 The School community (principals, teachers, parents and learners).
4.3 Friends and family (many who are also mathematics teachers).
4.4 The local District community (district officials and workshop presenters).
4.5 Professional associations – (in particular AMESA).

In the questionnaire of November 1999 teachers were asked: "What do you feel are the major benefits of participating in the PLESME programme?" Responses involved a range of benefits such as interacting with other teachers, developing confidence, gaining knowledge about mathematics, methods or the new curriculum, and motivational factors such as boosting morale and keeping teachers interested and stimulated.

The most commonly recurring benefit was 'gaining information' that included ideas, knowledge and understanding in relation to mathematics, mathematics teaching and the new curriculum. In November 1999 this was noted as a major benefit by all of the teachers, and four of the ten teachers listed it as the first major benefit. The second most recurring benefit was interaction with others. All of the teachers (except two) stated interaction with fellow educators as a major benefit and three of the teachers listed it first.

The same question was asked in July 2000, eight months later. At this point all of the teachers listed interaction with other educators and teachers in PLESME as a major benefit and five of the teachers

listed it as the first major benefit. Teachers expressed this benefit as follows: 'being part of a group' 'learning from other teachers in the group' 'it allowed me to participate with other mathematics educators' 'meeting teachers from different schools who are passionate about teaching maths' 'a rare opportunity to share different experiences of teaching with other educators from different schools' 'ideas from other teachers…learn to know more teachers with the same problems'.

Rosina's list of benefits of participating in PLESME reflects the increasing importance placed by teachers on this aspect of 'community' and also indicates the range of communities that she valued:

> The knowledge we gain from workshops.
> The chance of meeting people that we didn't know before.
> To be able to work with and know other teachers/schools in different provinces.
> To be able to work with our colleagues in Eldorado Park and to be so close to them and to be able to discuss problems that we encounter in our classrooms.
> To get a chance of attending conferences e.g. the Malati and the AMESA to see what other people do in their classrooms where learners will enjoy attending lessons.
> To get a chance of meeting you Mellony… [Rosina Questionnaire, July 2000].

The third, fourth and fifth points in Rosina's list above are particularly significant in the post-apartheid South African context and in relation to current changes in Education. Under apartheid, teachers from different race groups operated completely separately with no official platforms for engaging about education across racial groups. Apartheid worked in not only separating racial groups but also in separating teachers of different racial groups. Education was a highly segregated sector with differential funding and varying demands on teacher qualifications for racial groups. Until 1992, AMESA did not exist and its predecessor (MASA) was a historically "whites-only" professional association for mathematics teachers[26]. Rosina's list of benefits indicates a broadening of her engagement with communities beyond that of her mathematics classroom and immediate school community to teachers from other communities comprising different race groups from different areas and provinces.

[26] MASA in its inception was a 'whites only' organisation and it carried this baggage even after it deracialised. Furthermore deracialisation was uneven across the provinces. For example, MASA, in what is now the Gauteng province, deracialised in the late eighties. However there was some resistance to its deracialisation in other provinces such as the Western Cape.

In the final questionnaire of July 2000 teachers were asked 'Who do you talk to about mathematics education?' As in teacher responses to the list of benefits of participating in PLESME, teachers listed a wide range of individuals and communities with which they engaged about mathematics education. Delia's response illustrates with some richness the importance of various individuals and communities for both intellectual and moral *support*:

> I talk to my husband, an ex teacher, about maths methodology and ideas practically every time I get a fresh idea. He helps me with the planning and implementation (How will you teach it??)[27]. This has helped me tremendously because we have on so many occasions highlighted the positive outcomes and also the shortfalls. We have had many amusing moments debating and competing in maths games. The teachers in the maths department have been very supportive. We share our personal frustrations and disappointments as well as our pupils' good achievements. I rely on my PLESME group for support (especially Sam and Beatrice) on maths or maths education more general. My mother and sister have shown great support especially after a long day's work, I complain and they listen. I also share my achievements and my learner's achievements and they rejoice with me. Mr. Sulivan, who resigned from the GDE and is temporarily teaching at our school is still my mentor and always will be. We have developed such a good relationship during the past years. He encouraged and assisted me when I was asked to teach maths instead of biology. My subject head, Mr. Pieters is always ready to share ideas on how to teach a topic. Mr. Mossie and I attend workshops, get ideas from teachers from different schools and discuss which will be practical for our situation [Delia Questionnaire, July 2000].

Delia's response focuses on various individuals with whom she developed close relationships with as key elements of her support structure. Delia began by explaining the importance of the support of her husband who happens to be an ex-teacher. Such interactions give her a chance to reflect on her ideas, mentally prepare her lessons and get some external comment in a loving and relaxed environment (as indicated by her reference to amusing moments and playing mathematics games). Similarly she notes the importance of her long-term relationships with several individuals in her school community, in the PLESME community, and in her family for both intellectual and moral support.

[27] This extract is how Delia wrote it. That is, the contents of the bracket are not mine.

Other teachers similarly included individuals and communities relating to their families, PLESME and colleagues in their school and many included learners, parents and principals at their school, learners and teachers from other schools, their own children and members of other organizations such as a women's club and the National Union of Educators.

As discussed in Part 2.2, the nature of teacher discussions in relation to these communities changed over time. Teachers became more confident and willing to talk to people about mathematics education and Moses explained that the nature of interactions with members became more 'exciting' due to his increased knowledge. He wrote:

> Discussions with colleagues, family (educators), principal, foreign connections prove to be exciting due to new and substantive insights [Moses Questionnaire, July 2000].

The data above clearly shows that the teachers identified being part of a community - both the PLESME community and the broader mathematics education community - and interacting with members from other communities, such as families and unions, as both a product of and being productive of their learning experience.

Other data sources supported these findings. In May 1999 teachers were asked to provide a graphical representation of "Who I talk to about maths, my maths teaching, maths education and other related issues" (see Appendix 9). Similarly in the final questionnaire of July 2000 (see Appendix 7) teachers were asked: "Who do you talk to about mathematics education?" In these responses the same groups of 'communities' could be identified. These were:

1. The PLESME community (the teachers, presenters and myself as co-ordinator).
2. The School community (principals, teachers, parents and learners).
3. Friends and family (many who are also mathematics teachers).
4. The local District community (district officials and workshop presenters).
5. Professional associations (in particular AMESA).

As discussed in Part 2.2 of this chapter, the nature of teacher participation and practices and the status and confidence of teachers in relation to interacting with various communities changed over time. The nature of these changing practices and confidence is intricately connected with the changing forms of engagement and alignment with communities and the individuals that make up those communities. In this section on community I do not wish to retell the story of the changing practices of teachers in relation to the various communities, as was discussed in Part 2.2. I rather focus on the way in which teachers saw engagement and alignment in these communities as productive of (and a product of) their learning and the importance teachers placed on the *nature and ethos* of that engagement and alignment. I will deal briefly with these two aspects in relation to each of the five identified groups:

4.1 The PLESME community (the teachers, presenters and myself as coordinator)

As noted above, by July 2000, all teachers noted interaction with other teachers[28] in PLESME as a major benefit of participating in the programme and many noted it as their first major benefit. For example, Delia wrote in relation to their participation in the PLESME community:

> Meeting teachers from different schools (primary and high schools) who are passionate about teaching maths; being able to share ideas and frustrations about teaching maths and of the GDE; a very good support system which includes teachers, lecturers, professors etc who have specialised in maths… I rely on my PLESME group for support (especially Sam and Beatrice) on maths or maths education more general [Delia Questionnaire, July 2000].

Similarly many teachers noted the importance of presenters in the PLESME community bringing new ideas for teachers to engage with. For example Karl noted:

> They (workshop presenters) bring new innovative ideas, things you couldn't have thought about. Sitting by myself I don't think that I would have come up with those ideas. And they share their knowledge and experiences, which is great. And I think what also benefits us is that their knowledge comes from them being in contact with others, with other people as well so they

[28] In Chapter 3 I discuss the racial composition of the PLESME group. I provide evidence that all PLESME teachers regarded the mixing of teachers from different areas and race groups (who under apartheid had never been provided opportunity to work together before) as a positive aspect of their learning.

> bringing from other people, and they bring their own and they bring it to us, I think that is good [Karl Interview, June 1999].

Thus Karl noted the importance of 'knowledgeable persons' in a community to facilitate learning and also noted the importance of those persons having been in contact with a wider group of professionals in the field of mathematics education. It is this contact with the broader community that ensures that the ideas the presenters bring are both current and valued by the broader community. For many teachers being part of the PLESME community also provided 'affirmation' for teachers' ideas. Cedric sums this up:

> It (PLESME) has affirmed a lot of things for me that I was thinking about [Cedric Interview, June 1999].

Thus engagement and alignment to the PLESME community provided new knowledge, access to valued (by the broader profession) knowledge, affirmation of one's ideas and a forum for engaging about mathematics education with colleagues who provide moral support.

Furthermore, when teachers explained their learning in terms of engagement in the PLESME community and its practices, they highlighted several aspects relating to *the nature* of the engagement. While all the teachers highlighted the importance of participating in PLESME activities and the importance of gaining 'knowledge' 'ideas' 'information' and 'support,' eight of the ten teachers stressed the importance of the *ethos* of PLESME and its relationship to their participation.

These teachers stressed the importance of their 'ownership' and 'voice' in PLESME, and the way in which teachers were given professional respect that prevented 'dictations' on what they should do. The following quotes, from teacher interviews and questionnaires, illustrate the importance that teachers placed on these aspects of the ethos of the PLESME community in the production of teacher learning:

> The fact that PLESME was stretched over a longer period than your usual INSET workshops gave us a *sense of ownership* of the programme. This was further complemented by the fact that *we formed part and parcel of deciding how, what and how fast we develop*. The latter was made

possible by our coordinator that *consulted us* about the nature of certain aspects of the programme *instead of dictating* our very action. More importantly I believe this *gesture was sincere and was necessary to ensure the success of this programme*. The PLESME programme was *not judgemental* but developmental and also *did not dictate* how we should develop but rather exposed us to a number of aspects of our profession that we needed to formulate an opinion about [Karl Questionnaire, July 2000].

PLESME *does not dictate* to us how to teach but it supplements and enhances our knowledge… It does not present a model to fashion ourselves after but there is participation and discussions as well as sharing information [Ivan Questionnaire, July 2000].

I *felt part of* the programme… We had a lot of *personal interaction* with our coordinator – Mellony. *Never did the presenters make us feel that we were not qualified mathematics teachers*. We had a lot of encouragement and compliments…We were given *ample opportunities to criticize, evaluate and disagree* on certain issues, workshops etcetera [Beatrice Questionnaire, July 2000].

There was a *lot of interaction* amongst the team (PLESME) whereas with the *Department no interaction only instruction* given to us without understanding what to do. PLESME there was a sort of *recognition* and accreditation through certificates [Puleng Questionnaire, July 2000].

Workshop presenters are *interested in our viewpoint*, instead of just imparting information and thereafter having no contact with the group [Delia Questionnaire, November 1999].

The *genuine humanitarian interest* in educators enhances the participatory quality [Cedric Questionnaire, July 2000].

What I pick up is how different the GDE district treats us to workshops. Here *we are seen as a professional*… [Sam Interview, June 1999].

> In PLESME we see the big picture in maths education…the education Department, they do not treat us equally. This is sad [Sam Questionnaire, July 2000].

> [PLESME gives] *encouragement* and help… and participants are encouraged [Elaine Questionnaire, November 1999].

This aspect of the ethos of PLESME community that teachers chose to participate in, and align themselves to, is important because it provided the base and the mechanism for teacher learning in relation to the other four components of meaning, practice, identity and confidence. That is the practices of valuing teacher inputs, not dictating practices to teachers and treating all teachers as knowledgeable professionals provided the framework within which teachers constructed *meaning*, developed forms of participation and adopted a range of *practices*, developed *identities* and *confidence* in relation to becoming more professional mathematics educators.

In addition, the ethos of this community guided, enabled and constrained the meanings, practices, roles, identities and confidences that were available for teachers to adopt. The development of confidence that emerged from participation in and alignment to the PLESME community is discussed further in Part 5.

4.2 The School community (principals, teachers, parents and learners)

It is important to note that engagement with and alignment to the 'school' community was not new to teachers. The support of the school community is always important to teachers as it is the immediate community in which they conduct the practice of being a teacher and in which they engage about their practice and their profession. I would argue however that the *nature* of the engagement and alignment in relation to *mathematics education* changed as a result of teachers changed learning. That is because of teachers changed understanding and meaning, changed practices, changed identity and changed confidence in relation to mathematics education, engagement and alignment in the school community qualitatively differed in respect of mathematics education.

In Ivan's vignette and in Part 2.2, I explained and illustrated how teachers' status in their school community changed and that this was both productive of and a product of their increased participation in a range of practices (including the PLESME practice). I also explained with examples how teachers became more involved in various committees in their schools. In many cases teachers were especially invited to participate in these committees. Recall Karl wrote:

> I speak more freely to anybody willing to listen about OBE because this programme has empowered me with regards to OBE and I have therefore the confidence to do so… My new-found confidence as a teacher has led me to become *more involved in the organisation of the school*. *New committees that I now also serve on is our school:* the School Governing Body, the assessment committee and the soon to be school development team. The above can be directly linked to PLESME having had a confidence building effect on my teaching profession. I also tend to give more input into our subject meetings. It has been the first time that I have presented at a conference not even to mention giving a presentation [Karl Questionnaire, July 2000].

Similarly, in an interview, Sam emphasized his changing status in his community:

> I must say you get your status as well in your community, it's one of the good things, even with your children, your children see you as for example the other classes I don't teach, the children say Mr (Sam) will you teach us next year for maths please? [Sam Interview, June 2000]

Thus the nature of the relationships between teachers and individuals in these communities differed. Teachers interacted with their school community as people who had valuable knowledge and were confident to share it with others, and therefore the nature of the engagement and alignment to these communities was qualitatively different.

4.3 Friends and family (many of whom are also mathematics teachers)

As in the case of teachers' alignment to their school community, teacher engagement with family and friends was not new, but the nature of the engagement in respect of mathematics education qualitatively changed as a result of teacher learning. For some of the teachers their spouses were also

teachers (Cedric, Sam, Karl and Delia) and this provided a strong support base for them to engage about education. Many teachers gave anecdotal evidence of their increased interaction with family members and friends about their mathematics teaching, their ideas about the new curriculum and their ideas about education in general.

For example, Beatrice told a story of how she shared a mathematics challenge with a friend:

> And then one night when I was at home a friend of my husbands came in and he wanted to know what I was busy with. I was busy with your number patters and I showed him and he couldn't do them - and he was very upset and then he took some of my examples home.
> MG: Is he also a teacher?
> Beatrice: No he fixes these cash registers, he didn't like it at all. I spoke to him the other day and asked how he's doing. He said there are one or two that he is still battling with but he won't ask me until he tries. I also have one little boy in my class, his mother also speaks to me a lot about maths. So I mean I speak to quite a few people about what I have learnt from you people [Beatrice Interview, July 1999].

This story illustrates Beatrice's willingness to engage with others about mathematics. Many similar stories could be told that show the enthusiasm and willingness of teachers to engage with family and friends about mathematics or about education in general. The quote by Delia (on page 281) similarly illustrates an enjoyment of engaging about mathematics teaching with family and furthermore stresses the importance of the moral support she gets from her family and friends, some of whom happen to be mathematics teachers or ex teachers.

Such anecdotes indicate increased engagement (inspired by increased enthusiasm and confidence) in discussions about mathematics education with family and friends.

4.4 The local District community (district officials and departmental workshop presenters)

As discussed in Part 2 above there was a range of anecdotal evidence of the changing status of teachers (and resulting changing forms of participation) in relation to district advisors. Recall that Rosina

explained how she was ‘more free’ to talk to district advisors than before. She, and other teachers, explained that they shared ideas with advisors and challenged them when they disagreed. Thus, while engagement with members of the district community was not new, the relations between district advisors and teachers were qualitatively different. Teachers no longer feared the advisors and interaction was more reciprocal.

Many of the quotes included throughout this study reveal a stressful tension between teachers and education authorities due to the ‘dictatorial’ nature of the relationships between teachers and members of the education department. For this reason I argue that there was a lack of alignment (and two-way participation) of teachers with their local education district communities. While I would not go so far as to say that teachers had aligned themselves to this community, their increased confidence, sharing of ideas and challenge to district members is, I believe, a first step towards developing a basis for alignment to this community. The breakdown of hierarchical relations in the education system is implied in the change from a performance-based curriculum to the more competence-based Curriculum 2005 (see Chapter 2). The changing role of members of the education district communities from ‘inspectors’ (as they were under apartheid) towards supportive advisors is an important shift in education policy. What is illustrated in this study is the role that increased competence and confidence of PLESME teachers played in shifting district advisors roles ‘in reality’.

4.5 Professional associations (in particular AMESA)

Alignment to the professional Mathematics teachers association AMESA was seen as an important part of PLESME since it provided the opportunity for inducting teachers into the broader profession of mathematics education and extended the opportunities for teacher learning from the four communities (discussed above) into the broader national mathematics education community. For all the PLESME teachers engagement and alignment to the AMESA community was stated as a very important and enjoyable part of their learning. Here are some examples:

> I am not going “nuts.” I have met people at AMESA who think like I do. What a relief!… I will present at this conference every year and will attend it every year. After 5 years of teaching this is the best thing I have experienced [Sam Questionnaire, July 2000].

The conference was the best thing one has undertaken. The fact I met teachers from various provinces and all walks of life, made me gain knowledge more than I had anticipated…The conference created a platform for me to rub shoulders with more experienced educators… to suck more knowledge from them. When I was presenting my 'how I teach it', I knew that I was listened by other educators who will in return criticize me more constructively [Moses Questionnaire, July 2000].

The AMESA conference was excellent especially as a presenter who had to show people how I present a lesson to my learners. I was too impressed because they gave me more ideas on how I can make the lesson more interesting [Rosina Questionnaire, July 2000].

Initially I was anxious because it was my first time attending an AMESA conference. It was a great meeting, so many maths teachers sharing ideas… I use my AMESA booklet with the teacher presentations as a useful tool in my classroom… The teachers on the PLESME programme finally had an opportunity to bond and develop strong personal relationships with one another [Delia Questionnaire, July 2000].

Well worth attending. Lessons were interesting. Learnt a lot from other teachers. The word "Maths" has new meaning. See maths through the eyes of other groups. New ideas. As a presenter, I got a lot of support from friends. The people attending were very helpful. Everybody enjoyed the time. Made new friends. Spent time with teachers – also socially [Elaine Questionnaire, July 2000].

It was a very educational experience, learning different methods and exciting ideas from different educators from different places, even from overseas. Meeting people who were so willing to share their ideas and exchanging telephone numbers it was so fulfilling [Ivan Questionnaire, July 2000].

It was such a productive event whereby we met with other maths experts from different regions. Exposure to different ways of maths is fun. What I liked most was most of us who attended were

> given a chance to present and the comments were positive criticisms [Puleng Questionnaire, July 2000].

The above quotes provide evidence of a range of important aspects of engagement with this community that teachers identified as supporting their learning. These involve: affirmation of one's way of thinking (see Sam above); gaining knowledge, ideas and being listened to (Moses, Rosina, Delia, Elaine, Puleng); meeting teachers from other places (Moses, Ivan, Puleng); presenting ideas and getting feedback (Puleng), and the chance of developing stronger personal relationships with fellow teachers (Delia, Elaine). For some this alignment to the AMESA (and RADMASTE) community was closely linked to a strengthened identity and confidence in relation to becoming a more qualified *mathematics* educator:

> I knew little about them (RADMASTE and AMESA) but was glad to meet the Real People: Professors and Masters and Honours in Maths always seem to be people out of our reach. It was good to sit down and share a cup of tea and just speak to such 'clever' people. I know you won't like this word – but that's how I felt. They made me feel like a Master of Maths – I'm not too old to become one – what do you think Mel? [Beatrice Questionnaire, November 1999].

In summary:

In relation to all five groups of 'communities' listed above, I have provided evidence to show that teachers increased their engagement (about mathematics education) with members of those communities. Furthermore, I have provided a range of evidence to illustrate that the nature of teacher engagement in these communities qualitatively changed with time. The qualitative changes involved, in particular, increased confidence and enthusiasm on the part of the teachers to engage about mathematics teaching and mathematics education more generally.

This changing engagement and alignment to various communities was both productive of, and a product of, other changes in teachers learning in relation to *meaning*, *practice*, *identity* and *confidence* in terms of mathematics education.

Part 5: Teacher learning as evolving confidence

Closely tied up with teachers' new ways of being were prolific comments from all teachers that they were more confident. This confidence was expressed in a way that both described and explained teachers' learning. In this respect 'confidence' was both a *result* and a *cause* of learning. Furthermore confidence clearly related to the four components of meaning, practice, identity and community. Confidence was: a result and cause of increased meaning; a result and cause of increased participation; a result and cause of strengthened identities/status as professional mathematics educators, and a result and cause of increased alignment and participation with communities.

The use of the term 'confidence' had arisen sporadically throughout the data from the second interview in June 1999 until the final questionnaire in July 2000. The frequency of the use of this term increased as time went by. This prompted further exploration and data gathering on the meaning of 'confidence'. This part of the chapter is divided into two subsections:

5.1 The emergence of confidence as a central phenomenon in teachers' learning.
5.2 A focus on the phenomenon of confidence.

5.1 The emergence of confidence as a central phenomenon in teachers' learning

In the second interviews, six months into PLESME, only three of the ten teachers *expressed* that they were more 'confident.' Confidence in these interviews of June 1999 related to:

1. Classroom practice. For example: 'I am more confident in my class' [Sam]; 'it (PLESME) gives me confidence to stand in front of the children' [Moses].
2. Gaining increased understanding of the new curriculum. For example: 'The last time you interviewed me I didn't understand the outcomes, now I've got a good basis to work from, that makes me feel quite confident' [Delia]; 'Because we are more confident…the more confident the teacher is the more confident the student' [Moses].
3. Being involved with 'more informed' people. For example: 'Its very important to rub shoulders with people who are more informed than you and well educated so you can gain the expertise

they have and be confident as a teacher…if pupils do not understand I derive ways and means for them to understand. It makes me more confident and I have more people to refer to if I have problems' [Moses].

4. Others having more confidence in them as teachers. For example 'Puleng and I are discovering that they (management) have more confidence in us, they are more satisfied and the results speak for themselves' [Moses].

While other teachers did not use the word 'confident', an increase in confidence was evident in the June 1999 interviews of all of the teachers. Teachers expressed this confidence using phrases such as 'more effective' 'not scared' 'more relaxed' 'it's affirming' 'more positive' and 'I have more to say', providing evidence that all teachers were on a path of increasing their confidence.

Similarly in the questionnaire of November 1999 (four months later) there was further evidence of teachers increasing confidence. In this questionnaire teachers used a wide range of phrases, such as, 'more successful' 'enjoy what I am doing' 'teaching has become more exciting' 'improvement', that indicated their increased confidence. As in the June 1999 interviews, Sam and Moses used the term explicitly: 'I am a much better and confident teacher' [Sam] and 'The practice has tremendously changed because now one approaches the learners with confidence and with understanding' [Moses].

In the final questionnaire in July 2000 the frequency and distribution of the term 'confidence' (and other related phrases) had greatly increased. In this questionnaire, seven of the ten teachers used the word 'confidence' in various responses. Other related phrases used by these seven teachers were 'gave me courage', 'more boldly', 'more relaxed', 'more free'. The other three teachers expressed their increased confidence by using terms and phrases such as: 'my credibility has improved' 'receiving accolades' 'so easy' 'positive outlook…share achievements and rejoice'.

As in the interview of July 1999, the use of the term confidence (and other phrases) in the questionnaire of July 2000 related to:

1. Classroom practice. For example: 'I have more confidence in presenting the subject and asking questions' [Ivan]; 'I am now in a position to make my own mathematics programme with

confidence' [Moses]; 'the programme of class visits in the school boosted our confidence in class' [Puleng]; 'Building self-confidence as a teacher' [Karl], and 'I have more confidence in teaching OBE' [Elaine].

2. Gaining increased understanding of the new curriculum. For example: 'I have more confidence in talking about OBE [Elaine].
3. Being involved with other people. For example: 'If someone questions me I can answer them and give them an argument based on my pool of people I work with' [Sam].
4. Others having more confidence in them as teachers. For example 'The colleagues have more confidence in me because I share with them the new information' [Ivan].

However, in this questionnaire, two new categories emerged in relation to teachers' increasing confidence. These related to:

5. Increased and broader participation in activities relating to education. For example 'My new found confidence as a teacher has led me to become more involved in the organization of the school' [Karl].
6. An identification with mathematics teaching into the future and/or pursuing further studies in mathematics. For example 'I am 10 times better and more confident than what I was 2 years ago. I enjoy my "maths" teaching so much I will probably do it for a long time to come. Future Plans. I want to study and get my degree in Maths Education [Sam].

These categories clearly indicate that teachers' increasing confidence was closely interwoven with changes in *meaning* (Category 2 above), *practice* (Categories 1 and 5), *identity* (Categories 4 and 6) and *community* (Categories 3 and 5).

Ivan emphasised the links between confidence, classroom practice and community (and his changing status/identity in this community):

> I have more confidence in presenting the subject and in asking questions that are exciting to pupils. The children love my subject because it is not monotonous, they always look forward to my next period. When children tell you that they enjoy your subject and their results are

> improving and you also get a positive feedback from parents it is very encouraging. The colleagues have more confidence in me because I share with them the new information, they refer other children…Teachers from other schools invite me to ask for solutions, sometimes even over the phone [Ivan Questionnaire, July 2000].

Karl explained the link between his increased confidence and his increased participation in a range of activities. He explained that his increased confidence was produced by his participation in PLESME and resulted in increased participation in a range of practices.

> My new-found confidence as a teacher has led me to become more involved in the organisation of the school. New committees that I now also serve on… The above can be directly linked to PLESME having had a confidence building effect on my teaching profession. I also tend to give more input into our subject meetings. It has been the first time I have attended a maths conference not even to mention giving a presentation at the conference [Karl Questionnaire, July 2000].

Elaine illustrated the link between increased confidence, her ability to make sense of the new curriculum (meaning) and her changing forms of participation with her colleagues:

> I have more confidence in talking about OBE. I try to show the teachers the advantages of OBE, that teaching can be fun and that learners can enjoy it. I have learnt to express myself to adults. I have learnt that I can talk in front of adults. I have learnt to try and help teachers with problems with OBE [Elaine Questionnaire, July 2000].

Increased confidence was not only evident in what teachers said but was supported by my observations of teacher participation in workshops, their classrooms, with others in their school, at conferences with people from the broader profession of mathematics education. While the teachers' statements provided some insight into the interrelatedness of confidence with other components of learning, the extent to which 'increasing confidence' recurred as a central phenomenon throughout the data led me to explore the concept further.

The data above shows that the frequency of 'confidence' as an explanation for, and description of, teacher learning greatly increased over time. This is important to note, as it is likely that the delay in the emergence of confidence, as a *central recurring* phenomena, has resulted in many shorter-term research studies of learning overlooking its significance.

As discussed in Chapter 5, Lave & Wenger (1991) and Wenger (1998) appear to have overlooked 'confidence' in their emergent perspectives on learning. Perhaps this is due to the 'psychological baggage' that a term such as 'confidence' carries. Perhaps it is as a result of the difference in the nature of the contexts in which they are working, or perhaps it is that the studies that informed their emergent perspective on learning were not sufficiently longitudinal for confidence to emerge as a central recurring phenomena in learning as participation in a community of practice. Whatever the reason, since 'confidence' was unexplored in relation to the theoretical framework in which I was working (discussed in Chapter 5) it begged further *grounded* exploration in relation to this study. It is to this that I now turn.

5.2 A focus on the phenomenon of confidence

In November 2000 I interviewed each of the PLESME teachers on what they meant by their statements of confidence. I was hoping that by working in a grounded way I could construct a fuller meaning for 'confidence' from a social practice theory perspective, and to explore its relation, in more depth, to the other components of learning. Detailed notes were taken on what the teachers said about confidence. Later transcriptions were made of the interviews and from these I was able to code responses into various categories and sub categories. In a small number of cases, utterances were placed in more than one category.

Utterances were relatively evenly spread throughout the emergent categories. The emergent categories were similar to those that emerged in earlier interviews and questionnaires. They included: classroom practice, access to knowledge resources, access to community resources, confidence of others in teachers, increased participation, affective factors and understanding one's own limitations. The table below gives an indication of the distribution of teacher utterances relating to their explanations on confidence.

Table 7.4 The distribution of teacher utterances on 'confidence' [Interviews, November 2000]

Category (and range)	(f[29])	Exemplar utterances
1. Classroom practice Improved mathematical competence Improved methodology and ideas Approaches to teaching/learning: more input from learners, learner confidence and better class ethos	14 (5) (6) (3)	'A lot, a lot a lot (of change in confidence), because when I stand in front of the children I know what I am going to do…The children are not afraid to do anything in the class, they're asking questions they want to find more from what they have learnt…Yah they talk freely, they even come to me after lessons… and I am now open to them. I am no more as harsh as I was before (laughing)' [Rosina]. 'Whenever I step in the classroom – knowing it is a two-way process that on its own makes me more confident. It makes them confident learners. We interact in a very healthy way' [Moses]. 'It actually boosted my confidence, I would without hesitation teach learners through groupwork' [Puleng].
2. Access to knowledge resources in relation to: Mathematics Methods, Ideas, strategies New curriculum information	12 (4) (5) (3)	'By confidence I mean the command of subject, Ok the strategies in presenting the subject, the approach… You know personally when you are confident about the subject it is easier to impart it than when you are not sure…You yourself appreciate the subject and dig deeper or do further studies' [Ivan]. 'Confidence to me means that you do your work without struggling, you have resources, not only human resources but you also have learning materials, you have interesting ideas…' [Cedric]. 'So these workshops have given us ideas of how to approach the topic' [Delia].
3. Access to support resources in relation to: PLESME community AMESA conference community Other teachers/principal Other organizations/individuals in organizations	21 (12) (4) (2) (3)	'And then sharing with the colleagues in the group, if it didn't work, why it didn't work and what could possibly work so that also gave me a lot of confidence in the classroom…And I think the support that we get knowing people, like we know you we know the GICD, we know Paul Laridon, you know we've got personal contact with them I think that also helps us in a way because we know we can pick up the phone' [Delia]. 'Yah I say now we have given us the chance to attend conferences to impart our knowledge to people who have got more knowledge than us that on its own gives more confidence… gradually to be in your mist makes me more confident than ever' [Moses]. 'Also interacting with other teachers, how Mr X (his principal) came to support me' [Ivan].

[29] 'f' represents the frequency of the number of utterances relating to each category of confidence.

4. Others have more confidence in them as teachers. Teachers are accorded more status and recognition. Learners Teachers/ Principal Broader Community District	9 (3) (2) (3) (1)	'Others have more confidence in me, they (other teachers) are asking me to set papers and evaluate theirs, so it means they have confidence in me. Also interacting with other teachers, how Mr X (his principal) came to support me and wanted me for his school, its how it comes about and interacting with other teachers, like knowing guys like Cedric and Karl' [Ivan]. 'And I must say you get your status as well in your community, its one of the good things, even with your children, your children see you as for example the other classes I don't teach, the children say Mr Tune will you teach us next year for maths please…So that's the other confidence the children see how I work and how I approach certain things and they start to grow in confidence…' [Sam]. 'Even my, what do you call it, DC, comes to ask me nowadays what do I know what do I think about this whole thing' [Elaine].
5. Increased (and new forms of) participation in broader education activities involving: Other teachers Conferences Department Parents and community *Note: quotes also indicate participation in terms of challenging others or arguing one's point.*	15 (4) (3) (4) (4)	'For me it's the power that this project gave me. How to expose myself without feeling ashamed or guilty of what I know or what I don't know. Actually having that courage to go further than that take it further and give input. Give the ideas that I have and not be afraid that the ideas that I have may be incorrect or wrong or I don't know enough to risk that confrontation if it may be' [Karl]. 'Before we started this course if someone asked me what is OBE I would just rely on what I had read in the newspaper. So I couldn't talk to someone and say what I think OBE is because there was no confidence and after this course if somebody asks me I can still have an argument, can motivate… but you see the confidence also to train the other teachers in the department because I can explain what I want from them, or what is a lesson based on OBE' [Elaine]. 'The other thing which I've learnt is to go to conferences even with AMESA and those conferences we thought those were only for people with degrees and so on that's not for us and when I started with the conferences and so on I feel more comfortable talking in front of people and sharing ideas, its not where I'm this little teacher in this little classroom trying to do a little thing' [Sam]. 'I'm more free to talk to the DVCs (district advisors) than before because if I can argue a thing with them so that we can be able to come to an agreement, we never did that we were afraid of these people. When they come to us we see them as people who are coming to do something bad to us' [Rosina] 'I can share my ideas with other teachers from other schools, I can join in with the OBE thing and express my opinions…Yah, even when I am talking to parents now, its not where, how can I say, I can actually come up with examples and explain to them…' [Sam]

6. Affective factors Motivation Work with ease Encouragement from style and ethos of PLESME	13 (3) (2) (3)	'And when you see the response and you see the result then you are always motivated and your confidence is growing and your workplace becomes a nicer place' [Cedric]. 'Confidence to me means that you do your work without struggling, you have resources' [Cedric]. 'A lot of encouragement. I'll never forget the first day you came to film me and I did the graph, you know when I made that mistake…and at the end that was actually one of the strong points that you mentioned, I didn't expect that when you said the kids actually saw your thinking process…There you also gave me a lot of confidence…you made us feel that we were intelligent, that's how you made us feel good' [Beatrice]. 'That is what that self confidence, where it originates from I think basically we have been exposed to one another and we found out that people are not out there to get you. It's a situation where we want to assist each other I think that was the environment the PLESME group had' [Karl].
7. Understanding one's own limitations: Allow mistakes and reflection See space for growth and improvement	10 (4) (6)	'I was confident enough to invite Barry to do this part of the lesson and the kids will enjoy it. I have confidence in myself for inviting him. We are usually afraid to do this because it means admitting weakness. Confidence allows me not to have to know everything' [Ivan]. 'I can expose myself to what I know, I mean to other people and I am willing to say Okay fine, show me wrong, prove me wrong. What is your idea then? What I say is I am open let's learn. That is what that self confidence is' [Karl]. 'And also knowing that if it doesn't work for this lesson I can change my method and try something else, its not a matter of do it or die kind of thing' [Delia].

Clearly the categories are interrelated. The following quote reveals the interrelationships between categories 1, 2, 3, 5 and 6. That is, it shows the relationship between classroom practice, access to ideas, access to support, increased and new forms of participation and affective factors:

> Okay, before it was more or less a one-man show, you go to your classroom… There is no feedback at all, you haven't shared any ideas with other teachers… Being in a group that you could rely on you got quite a few ideas and this now stimulated my interest in developing worksheets, new teaching styles, being creative in the classroom… And then sharing with the colleagues in the group if it didn't work, why it didn't work and what could possibly work so that also gave me a lot of confidence in the classroom… And I think the support that we get knowing people, like we know you we know the GICD, we know Paul Laridon (Professor of Mathematics Education at Wits University), you know we've got personal contact with them I think that also helps us in a way because we know we can pick up the phone [Delia Interview, November 2000].

The table shows an emphasis by teachers on access to people as a supportive resource in developing confidence. This category receives the greatest number of utterances (21 in total). This concurs with the teachers' emphasis on this aspect in relation to listing the major benefits of their participation in PLESME (discussed above). While there are various references to the importance of the professional community at a macro level (9 utterances), belonging to the PLESME community features most strongly in this respect (12 utterances).

The categories that emerged closely relate to the four components of learning discussed in Parts 1-4 of this chapter, namely: meaning, practice, identity and community. Categories 1 and 5 indicate teachers' use of confidence in relation to changing *practice* (learning as doing) and *meaning* (learning as changing understanding and experience). Category 2 indicates confidence in relation to access to resources, in particular knowledge as a resource, which is closely connected to changing *meaning*.

Category 3 links confidence to *community*. Category 4 links confidence to *identity*. Category 5 links confidence to *practice*. Categories 3, 4 and 5 are closely linked in that confidence, in its derivation from support available from belonging to a broader community of professionals, is linked to teachers'

changing status/identity in various communities. This changing status is then linked to teachers' changing practices and the changing forms of (increasing) participation in those practices.

Categories 1-5 are similar to the categories that emerged in relation to teacher comments on confidence in earlier interviews and questionnaires (discussed above). The distribution of utterances in the categories is, however, different in November 2000. In the July 2000 questionnaire most teacher utterances were clustered in relation to classroom practice (the first category above). In the November 2000 interview 'community as a resource' became far more prominent (having the highest frequency of utterances). That is many teachers related their increased confidence to the resource of people. Category 5, relating to increasing and new forms of participation, revealed a new aspect of teachers' confidence that was not revealed in earlier data. It revealed the confidence in teachers to argue, to challenge and to justify (and be proud of) one's actions. The following quote illustrates this (see also the first, second and fourth quote in Category 5 of table 7.4):

> Like when you have your syllabus your HOD will tell me I have to cover everything and then just to please him I must cover everything but now I'm to a point where I can say listen there's no need for me to cover everything I've got the confidence and I say listen this is my time what I have… And the other confidence is how can I say its not where I would sit in my class, I don't know if you've picked this up, teachers don't want you to go into their classrooms, but to me it doesn't matter who is in my classroom you can come in when I'm doing, I'm confident in what I'm doing you can do whatever you want in my classroom I can justify what I am doing and why. In the past I would say no I don't want you in my classroom, just go away please if you come into my class I would just stop my teaching but now whoever comes it doesn't matter what is your ranking, inspector who else…' [Sam Interview, November 2000]

Category 6 links confidence to affective factors that result from teachers' access to a wide range of resources involving participation in various *practices* and having access to a particular kind of support incorporated within the ethos of the PLESME *community*. This 'ethos' is often undervalued in explaining teacher learning and in the design of INSET. The data here concurs with discussions on the importance of this aspect discussed in Chapter 3 and in Part 4 of this chapter.

Furthermore, in November 2000 an important additional category emerged in relation to confidence. This category (see Category 7 of Table 7.4) related confidence to understanding one's own limitations and viewing one's learning as a life-long process within the profession of mathematics teaching. Category 7 is especially interesting in that it provides us with insight into the notion of confidence, in relation to learning, in its own right. That is, it relates confidence to learning to become a *confident* 'masterful' professional mathematics teacher.

It is possible that this category of confidence emerged only in the final interview of November 2000[30] because of the longer time needed for teachers to develop their confidence to the point that they were able to accept that they did not have to know all there was to know about mathematics education in order to be confident, competent mathematics teachers.

The quotes in Category 7 reveal a shift in teacher's understanding of their own learning and the nature of learning in general. This shift resonates with a Socratic philosophy of learning - that it is better to know that you don't know, than to think you know - and that there is power in understanding one's own limitations. For example Ivan explained:

> Like for instance I was confident enough to invite Barry (teacher in PLESME) to do this part of a lesson and the kids will enjoy it. I have confidence in myself for inviting him. We are usually afraid to do this because it means admitting weakness. Confidence allows me not to have to know everything [Ivan Interview, November 2000].

Ivan's quote reveals that confidence enables him to accept that he does not have to know everything in order to be a competent professional mathematics teacher. In a dialectical cycle this in return produces confidence.

Similarly, many PLESME teachers changed their understanding of what it meant to be a competent professional mathematics teacher and began to see learning as an integral part of being a professional, irrespective of one's level of formal education. This new approach to learning was both a result of

[30] It is also possible that this aspect of confidence only emerged in the November 2000 due to the increased focusing and time provided to teachers (in interviews) to reflect on their ideas about confidence.

confidence, and provided teachers with increased confidence. For some teachers this new understanding of learning was linked to their confidence in changing classroom practices and the ethos of learning in their mathematics class. For example, in Category 1 of Table 7.4, Moses says 'knowing it (learning) is a two-way process that on its own makes me more confident'.

It is interesting that some teachers related increased confidence to their ability to create a more positive learning environment. For example, in Category 1 of Table 7.4, Rosina says 'the children are not afraid…they talk freely', and Moses comments 'we interact in a very healthy way'. In this way the aspect of *learners'* developing confidence is introduced. Teachers noted that their increased confidence allowed their learners to be 'more free' and to ask questions. This relates to the adoption of learner-centred practices prevalent throughout the data of all the teachers and links with teachers changing understanding of competence and learning (i.e. learning as a lifelong process in which one doesn't have to know everything).

In sum, the interviews of November 2000, as summarised in Table 7.4, provide evidence to support a construction of confidence as both a product and process of learning that involves dialectical movement towards mastery of the practice of being, and becoming, a professional mathematics teacher. This assertion requires further exploration and elaboration.

Theorising confidence as both a product and process of learning

The data from the final interview in November 2000 (which specifically focused on the meaning of confidence) seems to indicate that with time the nature, depth and scope of confidence (in relation to learning) increased for all teachers. The emergence of Categories 1-7, and the nature of the examples in the categories, illustrate that increased confidence is both a *cause of* (explanation for) and *effect of* learning. In this sense confidence is both a *product* and a *process* of learning.

Evidence provided in the table illustrates that teachers had indeed become confident in their level of mastery in the practice of being professional mathematics teachers. I use the phrase 'level of', as a qualifier of mastery, to indicate that my use of the term 'mastery' is primarily as an ongoing process, involving both being and becoming, that at any point in time can be experienced, by teachers, as a

product of learning. In this way teachers can experience a particular level of mastery that is achieved in relation to a particular aspect of their practice and their learning.

Mastery involved: confidence in what teachers had learnt and the meanings they constructed in relation to changing developments in their profession; confidence in their ability to participate in the various practices (and communities) of the profession of mathematics teaching; confidence in their ability to access resources to supplement their learning; confidence in their identities[31] as professional competent mathematics educators; confident acceptance that there was still much more to learn and a willingness and confidence to become a life-long learner in the profession of being (and becoming) a mathematics teacher.

In this respect, like the other four components of learning, confidence is both a product and a process inherent in teachers' learning to become professional mathematics teachers. Thus in the same way as *identity* involves *learning as becoming,* as well as the experience of *being* a person with a particular identity at a particular point in time, confidence involves *learning as mastery,* as well as the production of an experience of the achievement of a particular level of mastery at a particular point in time. In this way confidence, and mastery, are produced by and are productive of learning.

There is a range of data in Table 7.4 that supports the assertion that confidence is both a product and process of learning. For example the quotes in Category 1 show that increased confidence is largely a *product* resulting from improved knowledge about teaching and changing classroom practices. Similarly the quotes in Categories 2 and 3 show confidence to be a *product* resulting from access to resources such as 'professional' knowledge and the support of a broader community of people. However, the quotes in Categories 4 and 5 indicate that increasing confidence is both a result (product) of, and part of the *process* of teachers' changing identities/status. And confidence is a product of, and part of the process of, teachers' changing forms of participation in various practices and in relation to various communities. Similarly the quotes in Categories 6 and 7 illustrate that confidence is a 'growing' *process* that both results in, and is produced by, affective factors (e.g. motivation, encouragement etc.) and acceptance of one's limitations and openness to further learning.

[31] I use identity here in relation to both the identities teachers held themselves and the status or identities provided to teachers by others.

In summary

Teachers provided rich and textured explanations of the meaning of confidence that illustrate: the centrality of the concept in relation to their learning; the breadth of the concept; the interrelatedness between confidence and the components of meaning, practice, identity and community; and the way in which confidence enables, as both a product and process, mastery of becoming and being a professional mathematics teacher. This is an especially important claim of this study since the theorisation of confidence is grounded in the data, and while informed by a social practice perspective on learning, 'confidence' is not dealt with in the literature that has informed this study.

In teaching, teachers are constituted as knowing. Teachers as learners in an INSET context differ from other learners in other contexts such as schools or apprenticeship contexts. In this study there is evidence to suggest that teachers challenged this construction of 'a professional teacher'. Teachers expressed confidence in relation to *not* knowing and acceptance that indeed one cannot know everything but one can become a life-long learner within the profession of mathematics teaching[32]. This confidence and approach to learning enables teachers to experience a level of mastery as well as to embark on a process of developing ongoing mastery within the profession of mathematics teaching. In this way, mastery is constructed as an ongoing process that is simultaneously experienced at a point in time (in relation to a particular aspect of the practice of being a professional mathematics teacher) as an achieved product.

Finally, while I have provided a construction of confidence that is informed by the data and by a social practice perspective, more work needs to be done in order to theorise the place of confidence in relation to social theories of learning.

[32] Further research could examine how teachers integrate their newfound confidence of 'knowing that they don't have to know everything' with their learners and communities perceptions of them as 'all knowing'.

Conclusions

In this chapter I have both described and explained teacher learning within the PLESME practice in relation to the broader context of curriculum change. This description and analysis has been structured in relation to five learning components namely: meaning, practice, identity, community and confidence. Each learning component, discussed in Part 1-5 respectively, was structured in a way that was grounded in (and emerged from) the data. What has been described is the nature of the primary recurring phenomena that emerged from cross case analysis of the ten teachers who form the sample of this study.

I have provided evidence to show that learning was indeed about changing ways of being that could be related to five identified components of learning. By providing excerpts from teacher interviews, questionnaires, classroom observations and field notes I have illustrated that learning to become *confident* and competent (mathematics) teachers was about learning new ways of being that involved new forms of participation and immersion in particular *practices.* These practices were associated with particular *meanings* and *identities* that were valued on both a macro and micro level by various *communities* (e.g. curriculum designers, South African society, the general community of educators, the PLESME community, local school communities, local education district communities and the AMESA community).

In this chapter, I have analysed each of Wenger's (1998) components of learning within the context of long-term teacher participation in INSET. Due to the prolific occurrence of the term 'confidence' throughout the data, confidence was added as a fifth component of learning and its meaning has been constructed from the available data.

This chapter also points to various implications for the design of INSET as discussed in Chapter 3. PLESME drew a group of teachers together who had vastly different mathematical histories. Part 2 and Part 3 of this chapter suggest that the mathematical needs of teachers, with different mathematical histories, differ in relation to becoming professionalised *mathematics* teachers. The data provided in this chapter suggests that while all the teachers developed and experienced 'mastery' in relation to being and becoming professional mathematics teachers, for some the experienced level of 'mastery' of

the epistemic domain of mathematics was limited. The dilemma remains: how does one structure the learning of mathematics *per se*, within INSET for mathematics teachers, in such a way that all participating teachers, despite their mathematical histories, experience *mathematical* confidence and mastery to a level that supports the implementation of new forms of pedagogy?

As explained in Chapter 5, Wenger does not deal with confidence in relation to learning nor does he deal with limitations in the learning trajectories of those with limited histories in an area that might be central to the mastery of a practice. I have pointed out that it is possible that these have been overlooked in Wenger's (1998) work due to the empirical data that informs his work not being of a sufficiently longitudinal nature for such issues to emerge. I argue, in this light, that this is therefore one of the major contributions of this study. Due to the long-term nature of this study (spanning more than two and a half years of data collection) I have been able to explore the notion of confidence (and mastery) as a central component of learning over a sustained period of time within a community of practice.

Chapter 8: Conclusions

This study investigated mathematics teacher learning in relation to teacher participation in an INSET programme, structured to enhance participation in a community of practice, in the context of current South African curriculum change.

This study provided a thorough analysis of this context of curriculum change in a way that highlighted the tensions inherent in the design of the new curriculum and in the implementation of change in the transformatory context of a post-apartheid South Africa. The study shows the impact of these tensions on teachers learning about the curriculum change. In particular, the co-existence of contradictory education models (performance-based and competence-based) during this transition period has created multi-faceted challenges for the teachers in this study. The study further examined the new pedagogic and mathematical roles inherent in the new curriculum and explored the adoption of these roles by teachers in relation to their changing practices and the development of new identities.

Methodologically, the study offered insight into an approach to researching teacher learning from the inside of INSET in which the researcher performs the dual role of researcher and coordinator of the INSET. The study illustrates that performing both roles can enable a powerful dualism and reflexivity in the research. This study provides the 'teacher educator/researcher' with an approach to working with that duality. The study made a further methodological contribution in its dealing with ethical concerns, especially as concerns the problematisation of race, in the context of current INSET and research practices in South Africa and elsewhere.

Theoretically this study has critiqued the work of Lave & Wenger (1991) and Wenger (1998) in relation to the applicability of their work to the context of teacher learning. In particular, the study has taken issue with their work for sidelining the role of teaching in learning and for not adequately reconceptualising teaching in relation to their perspective on learning. Furthermore the study takes

issue with the absence of the notion of confidence in their work, which, as this study shows, is a central phenomenon of learning.

In the data analysis of teacher learning stimulated by participation in the PLESME practice, Wenger's four components of learning - meaning, practice, identity and community - all emerged strongly. In addition 'confidence' emerged strongly from the data and was added as a fifth component of learning and used with the other components to frame the analysis.

In the final chapters, the study illustrated, through rich and textured vignettes and quotes, that teachers' participation in the INSET community of practice involved the complex intersection of these five components of learning. The key contributions with regard to each of these were:

Meaning: learning as experience

The study has shown that teachers' increased participation in practices relating to making sense of the new curriculum, such as doing, talking, thinking, feeling, describing, interpreting, decoding and recasting, was productive of teachers experiencing aspects of the new curriculum as more 'meaningful'.

Practice: learning as doing

The study has illustrated how the changing practices and roles of teachers assisted in the development of stronger identities as professionals, as mathematics teachers, and as educators, by the teachers themselves and in their identification by the broader professional community. Through the vignettes of two teachers' lessons, the study illustrated the influence of mathematical histories on the nature of the implementation of new curriculum ideas in mathematics teaching, and on the development of teachers' mathematical trajectories. It showed that while all teachers moved towards mastery of 'new' practices of mathematics teaching, some teachers faced more challenges than others in integrating deeper mathematical understanding with new forms of practice.

Identity: learning as becoming

The study has suggested that while all teachers developed stronger identities as *professional mathematics teachers*, depending on teachers' mathematical histories, these identities differed in relation to where emphases were placed in relation to becoming professional, becoming mathematically competent and confident, and becoming teachers capable of implementing new curriculum methodologies. The study further suggested that numerous trajectories were available to teachers in relation to their histories and the learning opportunities afforded them through the introduction of a new curriculum and participation in the PLESME practice.

Community: learning as belonging

The study has provided evidence to show that, as a result of participation in the PLESME community of practice, teachers increased their participation in, and engagement with, other related communities. The study shows that, over time, teachers increasingly highlighted the importance of 'belonging' to various communities as a central part of their learning. Furthermore, the study has provided evidence to illustrate that the nature of teacher engagement in various communities changed qualitatively over time.

Confidence: learning as 'mastery'

This study has provided textured explanations of teachers' understanding of confidence. These understandings highlighted: the centrality of the concept in relation to learning; the breadth of the concept; and the interrelatedness between confidence and the components of meaning, practice, identity and community. The study argues that teacher expressions of confidence, in relation to the acknowledgement and acceptance of their competence, coupled with acknowledgement of their limitations and the adoption of identities as lifelong learners within the profession of mathematics teaching, indicate that 'confidence' is underpinned by a notion of 'learning as mastery'. This confidence enabled teachers to experience a level of mastery, as well as to embark on a process of developing ongoing mastery within the profession of mathematics teaching. In this way mastery has

been constructed as an ongoing *process* that is simultaneously experienced at a point in time as an achieved *product*.

Confidence, as a central component of learning, emerged unexpectedly from the study, and has been theorised as a critical addition to the four components of learning postulated by Wenger. The perspective on confidence that emerges is, however, tentative and initial. Thus, while the study has provided a construction of confidence that is both grounded in the data and informed by a social practice perspective, more work needs to be done in order to theorise confidence more fully, and to locate confidence in relation to social theories of learning in a range of learning contexts.

I have thus argued that the emergence of confidence as a central component of teacher learning is a major contribution of this study. Furthermore, I suggest that the delayed emergence of this notion of confidence, in relation to the process of teacher learning, has validated the longitudinal nature of this study and highlights the importance of longitudinal studies in further research on teacher learning.

Some implications for the design of mathematics INSET

In terms of teacher learning, in the current South African context, there is a dearth of knowledge about what kind of INSET works and what doesn't. In South Africa, questions such as these are acute because of the intensity of the challenges faced by the rapidly transforming education system. It is clear that a great deal of mathematics INSET has not facilitated much learning at all. Although the purpose of this study is not to critique the strengths and weaknesses of PLESME, the study's research and theorisation of teacher learning, within the PLESME community of practice, has significant implications for the design of INSET, particularly in the South African context. The most important of these implications are:

The importance of acknowledging the transformatory context of curriculum change:

This study provided a detailed analysis of various tensions inherent in the implementation of the new curriculum (and in particular the new mathematics curriculum) and described the experiences of the teachers in relation to these tensions. This analysis illustrated how the teachers in this study drew comfort and support from their participation in the PLESME practice. The study suggests that INSET projects should consider prioritising the provision of a supportive environment where teachers are able to acknowledge and articulate these tensions, air their frustrations and share workable solutions to the tensions.

The importance of long-term work with teachers:

PLESME worked with teachers over a two-year period. The study suggests that teachers' sense of 'belonging' to various communities, teacher identities as professional mathematics teachers (with an identification of the profession into the future) and teacher confidence largely developed in the second year of participation in PLESME. The study has argued that identity, community and confidence are central components of learning and that sustained participation over a period of time enables these components of learning to emerge strongly. Of course, this has implications for the cost of INSET and must be weighed up against the dilemma of localised situations where the learning of a few teachers is maximised while the majority of teachers receive little support.

The study does, however, indicate that the teachers involved indeed became 'leader' teachers in their schools and communities, and continued to actively embrace this role after PLESME meetings ceased. In this respect I suggest that the relatively high cost of interventions, such as PLESME, are justified.

The importance of locating INSET activities within a community of practice:

The site of PLESME was not school-based or institution-based. Rather the site for ongoing activities was the PLESME community of practice, located for some activities in schools, and for other activities in various overlapping communities of practice. The study suggests that the formation of a

strong community of practice, within PLESME, encouraged participation in overlapping communities and practices of the broader profession. Furthermore, these communities were a central resource for teacher learning, and enabled sustained learning and participation to continue after PLESME activities ceased.

The importance of developing teachers' *mathematical* identities:

PLESME drew together *teachers of mathematics* in the Senior Phase level with a wide range of different mathematical histories. The study revealed that while all teachers in this study developed stronger identities as *mathematics teachers*, teachers developed varying levels of mastery in the domain of mathematics *per se*. The study suggested that stronger mathematical histories afforded teachers the opportunity to foreground mathematical learning in relation to broader learning about the profession of mathematics teaching and curriculum change. Furthermore, weaker mathematical histories resulted in difficulties in integrating new curriculum ideas and methodologies while simultaneously maintaining a mathematical focus in teaching practices.

In relation to the importance of creating a supportive community for teachers that extended from the INSET practice into their mathematics departments, it was important that the INSET allowed access for all teachers of a particular level to participate. However, this 'open access' is likely to result in teachers with varying mathematical needs participating in the INSET. The study suggests that further research is needed to explore ways in which INSET can be designed so that all teachers develop a strong level of mastery of the epistemic domain of mathematics irrespective of their mathematical background.

The importance of creating a positive ethos and a focus on lifelong learning in INSET:

The study has described the nature of PLESME and has highlighted the importance of a shift in the approach to teacher learning from 'necessary change' or a 'fix-it' approach to stimulating life-long learning for learners who are already practicing professionals. There is substantial evidence in the study that suggests that teachers defined the PLESME practice partly in relation to it being 'not like' other interventions or department workshops they had attended, which they considered unsuccessful.

The study has provided a wide range of evidence, from teachers, of the importance of the ethos of PLESME in relation to their feeling 'ownership' of their process of learning, and in relation to their 'being heard', and in relation to their being considered professionals. Furthermore, this study, through its highlighting of the importance in the development of confidence, validates the importance of creating and maintaining a positive ethos. INSET interventions must acknowledge that their learners are special in the sense that they are already practicing professionals with a wide range of experiences that will influence the learning trajectories afforded to them through participation in the INSET.

The benefit of bringing teachers from different racial backgrounds together:

The study has explored various issues relating to the racial identities of the teachers participating in the INSET practice as well as the racial identity of the coordinator/researcher. Through a series of interviews with teachers that focused on the extent to which 'race' was an influencing factor on the practices of PLESME, one aspect came out strongly for all teachers: bringing together different race groups *supported* teacher learning in relation to being a professional mathematics teacher in a post-apartheid South African context. Furthermore some teachers advised that this aspect be replicated since interracial experiences are rarely provided by INSET. While the data suggests that the mixing of different racial groups and teachers with varying backgrounds was productive of powerful learning, the study also suggests that acknowledgement of possible racial tensions and sensitivity on the part of the researcher/coordinator is essential.

The importance of providing access to resources in relation to meaning, practice, identity, community and confidence:

The study suggests that in extended INSET, providing access to various resources associated with the profession, including participation and engagement with various meanings, practices, identities, communities and confidences, is a central activity with which INSET should concern itself.

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This study has provided a rich and nuanced exploration of the complexity of mathematics teacher learning within the context of rapid South African curriculum change. A constant subtext of the study has been to encourage researchers, curriculum developers and teacher educators to embrace this complexity, and deepen our understanding of it, rather than to simplify it. If confident mastery is to be achieved by professional mathematics teachers in South Africa, and elsewhere, then an appreciation of the fullness of teacher learning, in all its depth and intimacy, and in all its textured intricacy, must be woven into our day-to-day practice.

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Appendices

Appendix 3

Timeline of PLESME

MG refers to myself as the co-ordinator of and researcher in PLESME

PLESME	Months	Broader Education
MG meets with district advisors. Together they identify possible schools for PLESME. MG meets with principals and teachers to negotiate PLESME. *MG develops her research proposal.*	August – December 1998	Widespread teacher redeployments Implementation of Curriculum 2005 at Grade 7 level is uncertain
Finalisation of PLESME schools. School visits and interviews with teachers to establish needs and expectations. Finalisation of PLESME activities for the first term. Weekly workshops on current changes in education and the introduction of Curriculum 2005 begin. Classroom visits and video reflection with PLESME teachers.	January – February 1999	Official implementation of Curriculum 2005 at Grade 7 is postponed. The PLESME schools from Soweto are drawn into workshops run by a school in a predominantly white area. They are told by district officials to follow this school's scheme of work. The teachers from Soweto have no input into these workshops or the schemes of work.
Weekly workshops on interpreting Curriculum 2005 continue. Workshops focus on the mathematics changes in curriculum 2005, the mathematics outcomes, learner-centered methods in the mathematics class and practical ideas for working towards the new outcomes (especially the social, political, cultural and economic aspects which were absent from the previous curriculum).	March – April 1999	Teacher redeployments continue. School 'Easter' holidays begin. National Elections take place. Kader Asmal becomes the new minister of Education. 'Performance' in schools becomes a focus.
Weekly workshops continue. They focus on new mathematics 'content' areas such as statistics, patterns and graphs, and using newspapers to design mathematics activities. Other workshops focus on language issues in mathematics education especially relating to the implications for second language learners.	May – July 1999	Tensions arise when participating teachers from Soweto are compelled to administer examinations set by teachers in a predominantly white area. Mid year exams begin in June. Two PLESME teachers change schools but continue in the programme. School holidays begin.

In consultation with principals and teachers PLESME postpones workshops due to the strikes. Workshops are held in which teachers share their views on the strikes and we decide how PLESME should proceed during this period. A workshop is held on the meaning of 'teacher professionalism'. Some momentum in PLESME is lost due to the postponement of workshops and teacher morale is affected by the uncertainty of the implementation of Curriculum 2005 at Grade 7 level. A workshop is replaced by a discussion of teachers' feelings about teaching in the context of the uncertainty of curriculum change. Teachers express that they are tired, confused and '*gat vol*.' We discuss ways to adapt PLESME so as to take this into account. The last workshop for the term relates to mathematics resources and mathematics games. PLESME morale is high and momentum returns.	August – September 1999	Public service strikes begin. SADTU supports the strike by calling for a one-day strike by all schools. Many schools participate in the one-day strike. Soweto schools are however affected for more than two weeks. That is during this time classes are not being held although many teachers are at school. Implementation of Curriculum 2005 at Grade 7 level in 2000 is still uncertain. One week school holiday.
Workshops recommence (now every second week rather than weekly) and morale in PLESME is high. Workshops focus on continuous assessment and involve sharing resources on assessment and teachers design and share their end of year examinations. School visits and video reflection with teachers. PLESME goes on a fieldtrip to the JCE teacher centre, AMESA, GICD and RADMASTE offices. The final PLESME workshop for 1999 is on the 'history of maths'. Various PLESME presenters attend this workshop and PLESME teachers invite other colleagues. PLESME teachers throw an end of year party and express their appreciation of the opportunity to particpate in PLESME. Some PLESME teachers attend a two-day conference at which a mathematics teacher education organisation (Malati) presents the findings of their work over the past years. (The conference was during school hours so only a few teachers were able to attend).	October – December 1999	Implementation at grade 7 in 2000 is still uncertain. Tensions arise with Soweto schools having to write common assessments which they have not had any input into. Schools are writing examinations. End of academic year. School summer holidays begin.

MG presents a paper on mathematics teacher roles in the new curriculum at the SAARMSE conference in Port Elizabeth. School visits and the finalisation of the PLESME programme for the coming term.	January 2000	Curriculum 2005 is 'officially' implemented in Grade 7. Some schools locate resources for implementation while others continue with the old curriculum. Some Gauteng schools receive new textbooks, curriculum guidelines, progress maps and learning programmes.
Weekly workshops recommence. Workshops include presentations by teachers. Workshops tend to run over time due to the enthusiasm of teachers in discussions. Workshops continue to be coordinated and chaired by MG. However, teachers take more responsibility as to the content and pacing of the workshops. 'Outside presenters' are occasionally invited but most workshops involve PLESME teachers working together on issues. A PLESME teacher misses workshops because her school is preparing for the 'inspection.' Other teachers are waiting for inspection and share their insecurities and frustrations about whether they should focus on new curriculum ideas or stick to the previous curriculum for the inspection. Authors of the provincial Progress Maps are invited to present their work. Teachers provide authors with feedback on this document. Another discussion and feedback session is held with an author of the Mathematics Illustrative Learning Programmes. PLESME teachers provide a written critique of the progress maps and ILPs. Some workshops are held on integrating mathematics with other learning areas. Workshops are also held on new topical areas such as 'probability and the 'new' national lottery'. Teachers register for the AMESA conference. PLESME goes on a one-day fieldtrip to the Lenasia teacher centre and the local district offices. *MG presents her evidence of teacher learning as 'changing identity' to the MES conference.*	February – March 2000	District visits to schools. These visitors are humorously referred to by teachers as 'the squads' and are seen as inspectors. PLESME teachers begin to challenge district workers on their 'outdated' schemes of work that conflict with Curriculum 2005. In some cases district officials work well with PLESME teachers and draw on them as a resource for ideas and materials to share with other teachers in the district. School 'Easter' holidays.

Workshops continue to be run primarily by inputs by teachers. School visits and video reflection sessions with teachers. Teachers prepare and share ideas for their presentations at AMESA. A PLESME teacher invites PLESME to his classroom to demonstrate his approach to teaching and share ideas on developing teaching aids. A discussion is held on teacher experiences of Curriculum 2005. This is minuted by MG and submitted to the national Review Committee for Curriculum 2005.	April – June 2000	The new Minister of education, Kader Asmal calls for a review of Curriculum 2005 A one-day strike is called by SADTU. This means that four PLESME teachers from Soweto are unable to attend a workshop. (The strike was agreed at the last minute and it was too late to cancel the workshop). Tensions still exist between Soweto teachers and the districts due to the imposition of common assessments into which they do not have input.
PLESME attends the AMESA conference. Every PLESME teacher (except one who was writing examinations) presents a 'how I teach it' paper.	July 2000	School holidays during which the AMESA conference is held in Bloemfontein.
PLESME teachers discuss the sustainability and future of the project and working with more teachers in the area. PLESME teachers reflect on the summary of the Curriculum 2005 Review Report and various newspaper clippings relating to the report. Teachers express that they are pleased with the review as it addresses many of their concerns. PLESME teachers launch SOWELDO as an AMESA branch under which they will organise workshops for other teachers in the area. At least 50 teachers attend the launch. PLESME teachers organise a 'Math 24' workshop with teachers in the area. They organise free game kits for each teacher. At least 50 teachers attend. PLESME Certification Celebration. PLESME teachers receive their portfolios and certificates. PLESME is registered with SAQA. *MG visits Southbank University and explores the work of Bernstein for the purposes of curriculum analysis. She analyses some of her data and notices a need to explore teacher confidence further.*	August – November 2000	The review report for Curriculum 2005 is submitted to the NDE. Newspapers report that Curriculum 2005 is scrapped. Minister Asmal responds that OBE is here to stay. Teacher and public confusion results.

School visits to support teachers in their work for next year. *MG interviews teachers on what they meant by 'confidence' in questionnaires and interviews. MG locates the work of Wenger (1998) and begins to draw on this as a theoretical framework for analysis of the data.*	October – November 2000	It is re-announced that Curriculum 2005 'is here to stay' but will be revised and streamlined. A revision committee will provide a revised version in July 2001.
In 2001 MG continues to provide advisory support to the PLESME group of teachers who meet occasionally under the SOWELDO AMESA branch. MG co-ordinates PLESME teachers to attend the AMESA 2001 conference held in Johannesburg. Some PLESME teachers assist in the organization of the conference. PLESME teachers get together for three workshops to support each other in preparing for presentations at the conference. *MG focuses on analysis of the data she collected during 1999 and 2000.*	2001	

Appendix 10

A summary of classroom practices as recorded on lesson observation schedules

Primary teachers: ordered alphabetically

BW = boardwork

Teacher	Observation Item No.	Category number on observation schedule		
		Lesson 1	Lesson 2	Lesson 3
Ivan	1	3 ½	4	4
	2	1	2 ½	3
	3	1	3	3 ½
	4	2 ½	3 ½	3 ½
	5	2 ½	3 ½	3
	6	3	4	3 ½
	7	2 ½	4	3
	8	2 ½	4	4
	9	2	2	3
	10	1	3	3
	11	3	3	3
Moses	1	2	3	4
	2	1	2	3 ½
	3	1	1	4
	4	2	3 ½	3 ½
	5	2	3	3 ½
	6	2	3	3 ½
	7	2	3	3 ½
	8	2	3	3 ½
	9	2[1] (bw only)	4	4
	10	1	3	3
	11	3	3	4
Puleng	1	3	3	4
	2	3	4	4
	3	3	4	4
	4	2 ½	3	3 ½
	5	3	3	3 ½
	6	2 ½	3	3
	7	2 ½	3	3 ½
	8	3	3	3 ½
	9	2 (bw only)	3	3
	10	1	4	3
	11	3	4	4

[1] Where teachers only used boardwork in relation to this item they were given a score of 2.

Primary teachers continued:

Teacher	Observation Item No.	Category number on observation schedule		
		Lesson 1	**Lesson 2**	**Lesson 3**
Rosina	1	1 & 4	4	4
	2	1	2 & 3	4
	3	4	4	4
	4	2	2 ½	4
	5	2	2 ½	3 ½
	6	1 ½	1,2 & 4	3
	7	1	2 ½	2 & 4
	8	2	2 ½	2 ½
	9	1	3 & 4	4
	10	1	1	3
	11	2	2 ½	3

Note: For all of the above teachers there was a change in use of languages other than English in order to facilitate conceptual clarity. The switching of languages does not feature for the following teachers because the teachers do not speak the languages of all their learners.

Beatrice	1	3 ½	4	4
	2	3	4	4
	3	1	4	4
	4	3	4	4
	5	3	4	4
	6	4	4	4
	7	2, 3 & 4	3 ½	4
	8	3	4	4
	9	4	4	4
	10	/	/	/
	11	4	4	4

The fifth primary teacher is Cedric. His first observation schedule and video are not available as they were stolen along with a set of video equipment in March 1999.

Secondary teachers: ordered alphabetically

Teacher	Observation Item No.	Category number on observation schedule		
		Lesson 1	Lesson 2	Lesson 3
Elaine	1	3	4	3 ½
	2	2	4	4
	3	1 ½	4	4
	4	2 ½	3 ½	3 ½
	5	3	4	4
	6	2 ½	4	3 ½
	7	3	4	4
	8	3	4	4
	9	1	4	4
	10	/	/	/
	11	3	4	4
Sam	1	4	3	3 ½
	2	4	3 ½	4
	3	4	4	4
	4	3	3 ½	4
	5	4	4	4
	6	3	3	3
	7	4	3	4
	8	3	4	4
	9	4	4	4
	10	/	/	/
	11	3	3	4
Delia	1	3	4	4
	2	3	4	4
	3	3	4	4
	4	3 ½	4	4
	5	4	4	4
	6	3	4	4
	7	4	4	4
	8	4	4	4
	9	3	4	4
	10	/	/	/
	11	3 ½	4	4
Karl	1	3	3	3 ½
	2	4	4	4
	3	4	4	4
	4	3	3	3 ½
	5	3	3	4
	6	3	3	4
	7	3	4	4
	8	3	3 ½	4
	9	4	4	4
	10	/	/	/
	11	2	4	4

Appendix 1

Appendix 2

Appendix 3

Appendix 4

Appendix 9

Appendix 5

Interview guides for four sets of interviews

First (base-line) teacher interviews (February 1999)

Aims:

- to get a sense of how much teachers know about the new curriculum and their feelings towards it
- to understand the nature of teacher support they receive and the nature of teacher collaboration in schools
- what are teachers feelings about the new policy of a minimum 7hr day and what changes do the conceive that this policy might bring
- to understand what type of development teachers are themselves looking for in the course, how do they conceive of 'teacher development' 'teacher learning' or 'teacher change' in relation to such a course
- what further studies might be interested in after the course or possible career paths

1. How do you think maths should be taught so that pupils learn most effectively?

2. What are your views on the new curriculum? (What do you know about it? How do you feel about it? What do you think it will mean for your classroom practice?)

3. There are ten specific outcomes for mathematics. They are listed on the handout which you have been given. I would like to ask you some questions about the outcomes which relate to working with maths in various contexts and those relating to mathematical processes

   SO3 says " Demonstrate understanding of the historical development of mathematics in various social and cultural contexts."
   SO4 says "Critically analyse how mathematical relationships are used in social, political and economic relations."
   SO8 says "Analyse natural forms, cultural products and processes as representations of shape, space and time."

   How do you feel/ what do you think about, when you read that? (What does it mean for you?)

   SO9 says "Use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes."
   SO10 says "Use various logical processes to formulate, test and justify conjectures."

   How do you feel/ what do you think about, when you read that? What does it mean for you?

4. Who, if anyone, do you talk to about your maths teaching? (What are the ideas that you talk about? When, informally, formal meetings, often? What do you discuss at meetings? Do you ever share worksheets, tests etc?)

5. What are your feelings about the new policy of a minimum 7hr day? What benefits or drawbacks do you see this policy having?

6. What type of learning are you hoping this course will initiate?

7. What further studies or future career path, if any are you interested in pursuing after the course?

Second Individual teacher interviews – June-July 1999

Aims:

- to get a sense of their knowledge, attitudes etc about the new curriculum (and specifically the outcomes listed 3,4,8 and 9 & 10) and their feelings towards it
- to understand more about the nature of teacher support they receive (the communities within which they talk about their maths teaching and about education) and the nature of teacher collaboration in schools
- to understand how the teachers see their 'development' 'learning' or 'change' in relation to the PLESME course

1. How do you think maths should be taught so that pupils learn most effectively?

2. What do you understand the purposes of the new curriculum to be? (What do you know about it? How do you feel about it?

3. As you know there are ten specific outcomes for mathematics. They are listed on the handout which you have been given. I would like to ask you some questions about the outcomes which relate to working with maths in various contexts and those relating to mathematical processes

   SO3 says " Demonstrate understanding of the historical development of mathematics in various social and cultural contexts."
   SO4 says "Critically analyse how mathematical relationships are used in social, political and economic relations."
   SO8 says "Analyse natural forms, cultural products and processes as representations of shape, space and time."

How do you feel/ what do you think about, when you read that? (What does it mean for you?)

   SO9 says "Use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes."
   SO10 says "Use various logical processes to formulate, test and justify conjectures."

How do you feel/ what do you think about, when you read that? (What does it mean for you?)

4. What type of learning do you think this course has initiated? What aspects of the course do you think have particularly helped your learning. Any suggestions of how the course can be structured to assist your learning?

5. How has the stimulus of the course impacted on your classroom practice? What, if anything, have you been doing differently in your class?

6. I have looked at your diagram of the different people you talk to about maths education. First I want to ask you about how PLESME relates to your picture.

   What type of opportunities do you feel PLESME workshops or school visits provide you for talking about your classroom practice or maths education in general? In what way do you feel these opportunities assist your learning?

   How do you see the role of the workshop presenters in assisting your learning?

   How do you see the role of other PLESME teachers in assisting your learning?

   Do you share your PLESME experiences with other teachers in your school? or others? Explain.
   How have the other teachers in your school contributed to your learning?

7. Do you see any overlaps between your participation in conversations in PLESME with other forums for discussion on your diagram (for example, your department meetings, departmental workshops etc). Try to explain the connections, if any?

8. What learning, if any, do you feel the 'doing maths yourselves' part of the workshops achieves? How do you think this learning is enabled? Do you think that these maths activities which you work on will influence the way you teach mathematics in any way? Explain.

9. I found... interesting on you diagram - clarify, expand etc.

10. What are your views on common exams practices?

Third teacher interviews (August 2000)

An unstructured interview.
Aims: To explore the role of 'race' as a factor affecting learning in PLESME.

Fourth and final teacher interviews (November 2000)

Aims:

- to explore teachers' meanings in relation to confidence
- to explore teacher meanings of the new curriculum in general and Specific Outcomes 3, 4, 8, 9 and 10.

1. In your interview of …. And your questionnaire of …. You use the term confidence. I am interesting in exploring this concept further and would appreciate any further comments that you have on what you meant by confidence.

2. What do you understand the purposes of the new curriculum to be? (What do you know about it? How do you feel about it?

3. As you know there are ten specific outcomes for mathematics. Once again I would like to ask you about what they mean for you.

   SO3 says " Demonstrate understanding of the historical development of mathematics in various social and cultural contexts."
   SO4 says "Critically analyse how mathematical relationships are used in social, political and economic relations."
   SO8 says "Analyse natural forms, cultural products and processes as representations of shape, space and time."

What does it mean for you?

SO9 says "Use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes."
SO10 says "Use various logical processes to formulate, test and justify conjectures."

What does it mean for you?

Appendix 6

Questions of the first baseline questionnaire – January 1999

1. Write a paragraph explaining how a typical mathematics lesson runs in your class.
2. How do you think maths should be taught so that pupils learn most effectively?
3. How do you think your pupils learn maths most effectively?
4. Write a few sentences to describe what maths is.
5. Write down all the workshops you have attended over the past two years.
6. What are the main benefits you feel you have gained from attending these workshops?
7. Who, if anybody, do you talk to about maths teaching? What ideas do you talk about?
8. What information have you been given concerning Curriculum 2005 so far?
9. How do you think the new curriculum will affect your mathematics teaching? What will be the same? What will be different?

Appendix 7

Two questionnaires

Questions of the end of year 1999 questionnaire – November 1999

1. What do you feel are the major benefits of participating in the PLESME programme?
2. Discuss the way in which your classroom practice changed over the period of this year.
3. What do you believe were the benefits (if any) of having your lessons videod and reflecting on these afterwards?
4. What do you believe were the benefits (if any) of the fieldtrip to the JCE teacher center, the JCE library, the GICD and to the RADMASTE and AMESA offices?
5. How is the PLESME programme different to any other INSET workshops that you have attended?

Questions of the 'final PLESME questionnaire' – July 2000

1. What do you feel are the major benefits of participating in the PLESME programme?
2. What disadvantages are there of participating in the PLESME programme?
3. What changes, if any, have you experienced in your classroom practice over the past two years?
4. In what way, if any, has your relationship to other maths teachers, other teachers, principals etc. changed over the past two years? Explain.
5. Describe your involvement in mathematics education activities or general school organizational activities over the past year. Has PLESME had any effect on these activities? Explain.
6. What do you believe were the benefits (if any) of the fieldtrip to the Lenasia teacher center and the district offices? Have you visited them since?
7. Describe your experiences of the AMESA conference. (Personal, mathematical, educational, as a presenter, meeting others etc. – likes, dislikes, advantages, disadvantages etc.)
8. How is the PLESME programme different to any other INSET workshops that you have attended?
9. Who do you talk to about mathematics education? Explain the nature of these talks – how often, one-way or two-way, sharing ideas or debates, personal frustrations, etc. You can use tables, lists or diagrams or any other means you find suitable.

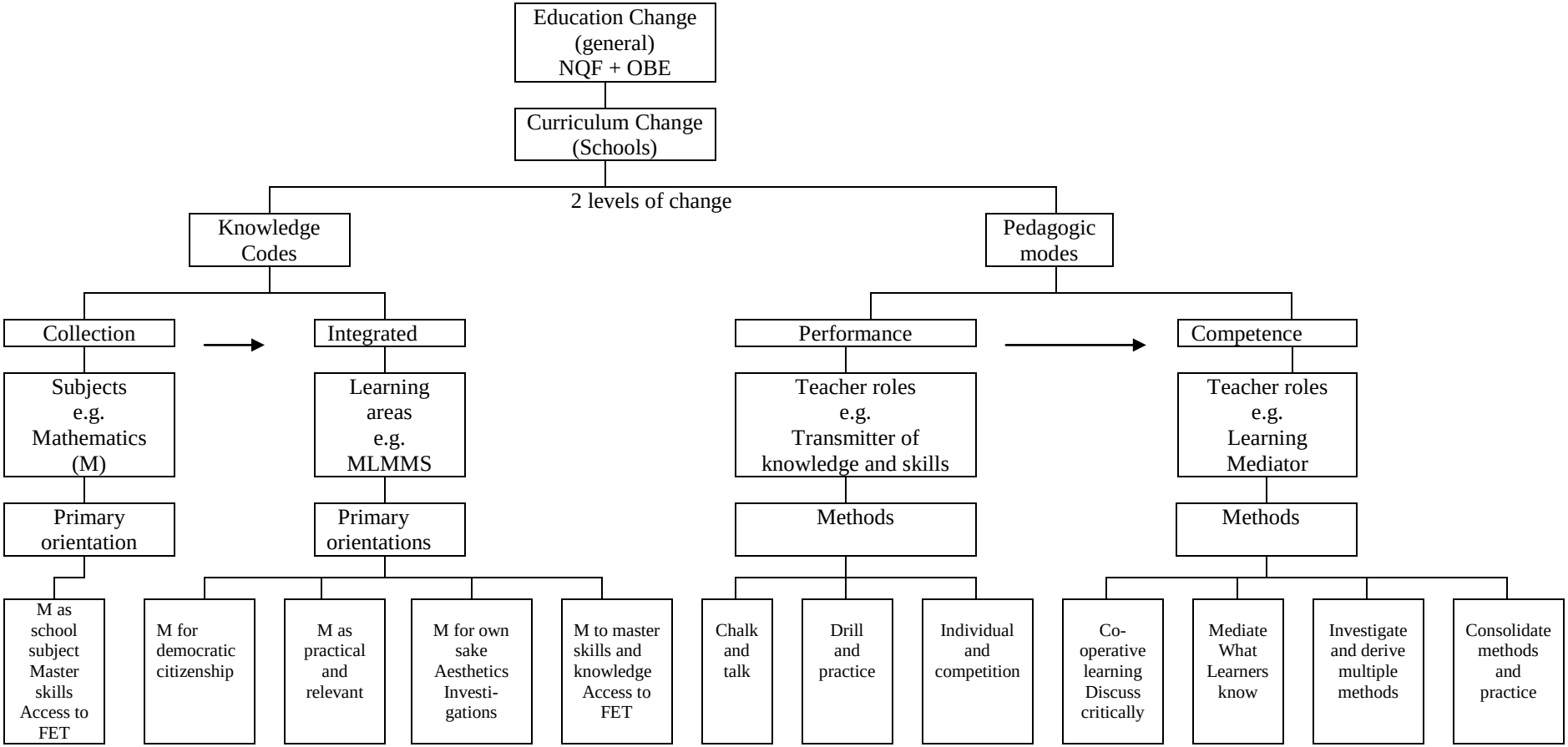

Figure 2.4: A Diagrammatic Summary of Mathematics Curriculum Change in South Africa