Part II

Researching teacher education: diverse orientations, merging messages

6 Holding the past, living the present and creating a future: trends and challenges in research on mathematics teacher education

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Introduction

Mathematics teacher education is a complex and layered domain of practice. It includes a wide range of distinct sites: pre- and in-service education (elsewhere described as preparation and professional development); primary and secondary education;[1] urban and rural education. At the same time, with its ultimate concern being mathematical learning in school, it attends to teachers' fostering of that learning, and then to teacher educators' fostering of the learning of teachers. Of course, we can extend these layers outward – thinking yet further about the fostering of the practice of teacher educators. As with any social practice, teacher education anywhere is also enabled and constrained by its socio-cultural and political context, leading to varying policies and practices in mathematics teacher education across national contexts. And so too research related to mathematics teacher education.

In South Africa, we continue to work in a socio-cultural and political context deeply scarred by apartheid education. Elsewhere (Adler 2002a), I have described how, in teacher education in South Africa, we need to simultaneously work with repair (apartheid did damage), redress (apartheid was constructed by and productive of inequality), and reform (to produce a thriving democracy and supportive curriculum). Poised as we are now to celebrate ten years of a democratically elected government, apartheid's legacy and the increasing disparities that mark a globalising world are painfully obvious. In the opening chapter of this book, with its focus on curriculum policy, research and practice, Vithal and Volmink talk of roots, reforms, reconciliation and relevance as they capture the multi-faceted context of curriculum in pre- and post-apartheid South African mathematics education. A focused history of teacher

education in South Africa, its present and future challenges, is discussed in detail by Welsch (2002). Neither need repeating here. Together, however, these analyses provide important reminders of the history that shapes our present. At the same time, and critically so, they offer comfort and inspiration as they capture work already done and currently under way. Holding our past, living our present and imagining and creating a better future lies at the heart of what I would call the ethos of much of the research and development work in South African education, and so too in teacher education.

Many of the layers and complexity of mathematics teacher education and related research in South Africa are in focus in each of the three following chapters of this book, as is an ethos of past, present and future. I will return to comment on each of these later. This chapter provides an overview of research related to teacher education in South Africa that has been published and/or discussed in Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE) conference proceedings over the past decade.[2] It offers a complementary analysis to those following in the next three chapters. My task here is at once more specific and then more general. It is more general than each of the chapters following in that it looks at trends in research related to teacher education over ten years across all published papers in the proceedings. At the same time the overview is very specific in that it is restricted to a particular 'community', participants in SAARMSTE over the past decade. Even within South Africa, this will not capture all research related to mathematics teacher education.

The focus on SAARMSTE proceedings is, nevertheless, illuminating. As will become clear through the chapter, there are discernible trends. And these raise questions about how we have come to constitute ourselves, what has come to be focused on, what has and has not been made visible, and why. In order to engage these questions, the chapter relates the overview of SAARMSTE papers to international trends. For it is in the similarities and differences between what has come in and out of focus in both arenas that we can reflect on challenges that lie ahead. Hence my task, too, is to hold the complexity of the field, while looking back on its past and imagining its future.

I begin the chapter with a brief discussion on the underlying assumptions and analytic framework of this text, as these explain further the lights and limits of a focused review as given here. This is followed by an examination of inter-

national trends in research related to mathematics teacher education, as revealed in two international handbooks, the first published in 1996 and the second very recently in 2003. Together, an analytic frame and an international overview provide a space within which to describe and reflect on trends, orientations and challenges for research, policy and practice in mathematics teacher education in South Africa.

Some underlying assumptions that inform the development of this chapter

The overall orientation to research that underlies the discussion in this chapter is of research as social practice, and thus not as a neutral domain. What research comes to be done, and where and how it is published, shapes and is shaped by, on the one hand, networks and communities of researchers – who and where they are, and relations among them. On the other hand, considerable influence is exerted by the 'rules' that regulate research practice; these would include how funding is accessed and distributed, and how conferences, journals and other ways in which research is disseminated, create boundaries of legitimacy.[3] This chapter, which is a meta-analysis of research in teacher education, does not and cannot claim some unassailable truth about teacher education research in South Africa. It can reflect on and describe how the field (at least through some of its public artefacts) has come to be constituted, what trends, questions and orientations are visible, and what challenges this presents. Inevitably, the description will be a partial view of the field, drawn as it is from a selection of publications. The SAARMSTE community is a significant one in mathematics education research in South Africa. It is, however, relatively new and still small. Much lies ahead.

Just as the assumptions that have guided this paper are important, so too is the framework that came to be used to organise the 'data' – the numerous papers, long and short, published in ten years of proceedings.

What counts as research related to teacher education and how is it identified?

Precisely because the domain of teacher education research is so broad and multi-faceted, it quickly became obvious that some kind of framework was

needed to systematically identify what could count as research related to teacher education. Simply, which papers in the proceedings should be included in this review, and why? In 1999, Krainer and Goffree (1999) published a review of mathematics teacher education research in Europe. This review was undertaken as part of the work of the European Research in Mathematics Education community. In the review Krainer and Goffree distinguish (and include) four different kinds of research that have come under the broad banner of teacher education (and) research.

They focus first on *research in the perspective of teacher education*, wherein they include research that focuses on teachers' mathematical beliefs, teachers' knowledge and aspects of teaching. None of these are investigations into teacher education in the first instance. However, the results of the research 'can be used as a basis for designing learning environments in teacher education programmes' (Krainer & Goffree 1999: 223). This is contrasted with *research in the context of teacher education*, which includes foci on teachers' learning through professional development, the gap between what teachers learn in pre-service training and their work in school, and changes in teachers' beliefs and practices. Here there is a direct concern with the use of the research in teacher education. However, teacher education practice itself is not the object of the research. Hence the third category, *research on teacher education*, where teacher education itself is the object of research, and the focus is on interaction processes within teacher education. The fourth category is *research as teacher education*. Here, the activity of research is in the foreground as a means for teacher development. Included here are all forms of action research and reflective practice, where teachers reflect on and/or research their own practice as a means for improving/learning more about their practice.

Through this set of categories, Krainer and Goffree produced a review of research in the field of mathematics teacher education in Europe and revealed that most of this research falls into the first two categories: research on teachers' beliefs, knowledge, learning and changing practices predominated. They were also able to see how various kinds of research were distributed across contexts in Europe. They pointed out that much had developed and been learned. Most interesting however, was the observation that the practice of mathematics teacher education itself had remained a black box.

I have used this categorisation of research in the field of mathematics teacher education to first identify and then analyse relevant papers across SAARMSTE proceedings for the period 1992–2002.

An international perspective

It is beyond the scope and goal of this chapter to provide a comprehensive review of all research in the field of mathematics teacher education. What I have selected to reflect on here are the chapters that focus on teacher education in each of two international handbooks on mathematics education, both published by Kluwer Academic Publishers, and that appeared seven years apart: the first in 1996 and the second just recently in 2003. These chapters, and the time between them, provide a perspective on how the international field of mathematics education constituted significance in mathematics teacher education and related research over the time span of the SAARMSTE review in this chapter. It is interesting to compare, even at a superficial level, what was placed on the agenda in 1996 that remained in focus in 2003, what disappeared, and what is newly in focus.

In the first handbook (Bishop, Clements, Keitel, Kilpatrick & Laborde 1996), Section 4 includes a focus on teacher education. Four chapters focus on the relationship between research in mathematics education and teacher knowledge, on pre-service and in-service teacher education, and on teachers as researchers.[4] In Krainer and Goffree's terms, the first chapter falls within *research in the perspective of teacher education*. The concern here is with research in mathematics education and its implications for the professional knowledge of mathematics teachers. This is coupled with the difficulties of productive and constructive relationships between researchers and the outcomes of research, and with mathematics teachers and their classroom practice. In other words, in focus here is the *relationship between research and practice, and the gap between them*. The chapter on *pre-service teacher education* compares systems, programmes and curricula across different national contexts. The concern here is with research that can illuminate the preparation of mathematics teachers and how comparative research provides a fruitful context for identifying common problems (i.e. problems constituted by the practice of teacher education) and then those that are context specific. What is brought into focus here is the *relationship between research, educa-*

tional policy and educational systems, and so too how research on teacher education (and pre-service curricula in particular) can/should influence policy and shape systems. The chapter on *in-service teacher education* presents a case study of a teacher and her participation in, and learning from, an in-service programme. The concern here is with the integration of theory and practice in teacher education. This concern is carried through into the chapter on *teacher research or research as teacher education*, where research or inquiry by teachers themselves provides a context for such integration. In focus in both these dimensions of research is the *theory-practice gap, and its implications for teacher education practice and the learning of teaching* – issues so well known and yet elusive in teacher education research and practice.

In the second international handbook (Bishop, Clements, Keitel, Kilpatrick & Leung 2003), Section 4 also includes four chapters on teacher education.[5] Concern with the integration of theory and practice in teacher education continues, as does debate on mathematics teachers as researchers. Together these reveal an ongoing challenge as to the relative roles of teacher educators and practising teachers in research in the field of teacher education. A core issue in teacher education and related research thus remains its own practice. Research on mathematics teacher education, and research as teacher education, are central to understanding and improving this critical field of practice.

And shifts in attention and foci are also evident. The first of the chapters in the current handbook on mathematics teacher education discusses a concern we share here in South Africa, and that is the regulation of the entry of mathematics teachers into the profession. In 2003, therefore, an issue in the foreground is the challenge of the massification or opening up of access to mathematics in school, at the same time as there are increasing shortages of people choosing to become mathematics teachers. As I write this, the new FET (Further Education and Training, Grades 10–12) curricula are coming on board in South Africa, with a requirement of mathematical literacy for all. At the same time as attempting to provide this mathematical access for all, we face the fact of fewer and fewer school leavers and graduates in mathematics coming into professional training. Stephens (the author of the handbook chapter) asks who is likely to staff mathematics departments in school, and how will they be learning mathematics for teaching? The orientation in his chapter is towards policy and systems for mathematics teacher education, carrying through issues on pre-service teacher education pointed to in 1996,

though with a different urgency and problematic. Here the focus is on provision of teachers and the consequences for curricula in teacher education.

Following this chapter is a chapter concerned with the mathematics in mathematics teacher education, and with a position that learning mathematics for teaching involves specialist knowledge (which by implication is not usually offered in tertiary courses in mathematics). This foregrounding of the production of mathematics teachers and their mathematical know-how for teaching is reinforced in the closing chapter on professional development. This chapter has a strong focus on rich mathematical tasks that foreground critical dimensions of the mathematical work of teaching, and hence are appropriate to teachers' mathematical development in and through teacher education.

The field has grown and, as is a condition of social life, the ground has changed. There are critical issues now in the preparation and in the ongoing professional development of teachers, a function of the massification of mathematical access, increasing conceptual demands embedded in new mathematics curricula, and the simultaneous 'shrinking' of interest and status in the profession. This situation brings to the fore the significance of the mathematical preparation of and for teaching, and so illuminates the challenges for research, policy and practice, and their inter-relation.

We can draw out implications for research from this broad brushstroke picture of the international field. We need research at the level of policy and systems, research which can consider how various dimensions – curriculum policy, teacher education policy, the status and growth of the profession and the systems of education that produce teachers and support teaching – interact to support student learning, and so access to mathematics. We also need to know more about (i.e. understand so as to be able to improve) the actual practice of teacher education. In particular, we need greater understanding of the mathematical demands of teaching in current conditions and how these manifest themselves across wide-ranging classroom contexts. At the same time, we need to continue to work to understand better and be able to work productively with the gap between theoretical and practical knowledge of teaching, between teacher educators and teachers as agents in the field of mathematics teaching, and between research and practice.

With a framework for thinking about research related to mathematics teacher education, and its elaboration through a perspective on shifts in the

international terrain, I now move on to a review of the research reported in SAARMSTE. What research in the field was identified in SAARMSTE's early years, and what has remained, slipped out of view and come into focus in the later years? How do these constancies and changes relate to the wider field of research related to mathematics teacher education, and to the focused chapters on teacher education research in South Africa that follow this chapter? I am aware that as I pose these questions, the framework constructed here makes the 'what' of mathematics teacher education research visible. The 'how' (theoretical and methodological orientations) is out of focus – indeed the 'how' has been rendered invisible. Where possible, I bring these matters into focus in the review below.

Research related to teacher education in the development of SAARMSTE

I have organised the review into a tabulation of the number of papers in each of the categories described above. I used Krainer and Goffree's categories to identify relevant papers and the object of focus in each paper. At the same time, I examined aspects of the empirical field of the research reported, in particular whether it concerned pre- or in-service teachers, and at the primary or secondary level; as well as aspects of the methodological orientation evident in the research reported.

This somewhat simple framework of analysis did not translate into a simple process of identification. Conference proceedings, SAARMSTE included, place a space limitation on papers offered, and so in a number of cases there is an under-description of the study from which the paper is drawn.[6] There were cases where it was not possible to clearly discern the orientation of the research – theoretical orientations and conceptual frameworks used were often absent. Nevertheless, interesting trends have emerged, and these are evident in the table opposite.

Over the years, interest shifted *from a greater focus on secondary settings, to primary settings, with an interest in both* reflected relatively evenly in the last few years. Research related to teachers *in-service predominates over pre-service* as does *case study research*. In the main, what is reported is a study of a particular teacher education programme, or a particular teacher (or small group of teachers). A small minority of papers employed a large-scale survey

Table 6.1 Foci over ten years: 1993–2002

		Year										Overview comment on trends
		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	
Total no. of papers	Simple count	5	5	5	6	14	9	9	14	6	8	Major increase in 1997.
Primary or Secondary	Ratio of primary: secondary (no. neither/ both)	1:4 (0)	1:4 (0)	2:3 (0)	1:3 (1)	4:8 (2)	6:3 (0)	3:4 (2)	7:5 (2)	3:2 (1)	3:3 (2)	Shift from more secondary to more primary to balance.
INSET or PRESET	Ratio of INSET:PRESET: (no. neither/both)	3:1 (1)	4:1 (1)	4:1 (1)	4:0 (1)	10:4 (0)	8:1 (0)	8:1 (0)	9:4 (1)	6:0 (0)	6:0 (1)	Inset dominates.
Small scale case study (CS)	No. of papers reporting a case study	3	5	3	3	13	9	7	10	4	5	Case studies dominate. Two cases of large-scale studies. Some papers theoretical or focused on research methods.
Research on the perspective of teacher education	Papers on teacher beliefs, knowledge, aspects of teaching	1	3	3	2	8	3	4	6	3	2	Consistent interest in teacher beliefs and knowledge.
Research on the context of teacher education	Papers on teacher learning; impact of TE; gap between preset and school	1	0	0	1	4	5	4	5	2	5	With increase in 1997 comes focus on impact or learning from INSET.
Research on teacher education practice	Papers reporting research on TE itself, or on methods of researching TE	0	2	2	2	1	1	1	3 (method)	1 (method)	1	Very few studies here and then on PRE-SET. In-service teacher education itself, as in Europe, is a black box.
Research as teacher education practice	Action research by teachers as part of their TE	3	1	0	1	0	0	0	0	0	0	Action research present in the early years, then disappears.

or a test of some kind, either on teachers themselves, or on their learners, and only two of these were relatively large-scale (Kulubya & Glencross 1996; Austin et al. 1999).

Dominance of INSET and issues of change

Through a focus on the 'what' we can see clearly that research here has predominantly been *in the perspective* and *in the context of teacher education*, and on *in-service teacher education* more specifically. There has been, and continues to be, a concern with and interest in teachers' beliefs about mathematics and about pedagogy, as well as with their knowledge of various topics in mathematics. Research in the context of teacher education emerges in force in 1997, partly as a function of the growth of SAARMSTE in general, but nevertheless as a reflection of a new emphasis on the impact of in-service programmes. Having been part of the context that produced this shift, it is possible to point, on the one hand, to the influence of funding practices post-1994 and a demand by funders that mathematics teacher education programmes demonstrate their impact; and, on the other, to the influence of the increasing formalisation of professional development programmes.

What threads across this research into the perspective and context of teacher education is a concern with 'change': questions are posed about what teachers' philosophical beliefs are about teaching and/or mathematics, and whether and how these should or do change; and about what teachers know about various topics and/or processes in mathematics and whether and how these should or do change. A concern with change, and so with research related to change, makes sense in the South African context: the 1990s were constituted by change in all domains of social and political life and particularly in the domain of schooling.

The emergence of a stronger focus on aspects of mathematics

Together with the shift in 1997 to concerns with the impact of INSET, there is a visible shift of attention to specific aspects of mathematics in curriculum reform in South Africa, and related questions for teacher education. Papers related to critical and ethnomathematics education (eg. Vithal 1997), mathematical modelling (eg. Lebeta 1999), learner-centred mathematical practice (eg. Brodie 1998, 1999) and the question of the specificity of mathematical

knowledge for teaching, or 'conceptual knowledge in practice' (eg. Adler 2002b) are all part of the collection of research related to mathematics teacher education in recent SAARMSTE proceedings.

These focuses on INSET, on change and on aspects of mathematics in teacher education research mirror shifts in the international arena and are taken up directly and indirectly in the chapters by Mellony Graven and Chris Breen that follow in this book. Graven's analysis of INSET design brings to the fore central dilemmas in INSET, one of which relates to the mathematical in teacher education. And Breen provokes our thinking about change, firstly in terms of the shift noted above to formalising professional development, and secondly in terms of the notion of change, and whose business mathematics teacher change is. Ultimately, in a discourse of change, teachers will always be found lacking – as changing either not enough or not in the right way. Reporting on a teacher development research project (aspects of which have been reported in SAARMSTE proceedings), Adler and Reed (2002) describe the shift in the language they used from 'change' to 'take-up' precisely because of how the notion of change inevitably produced a deficit discourse in relation to teachers.

Where is research related to pre-service mathematics teacher education?

In its absence, research into the context of and/or the pre-service preparation of mathematics teachers, particularly at the primary level, becomes starkly visible. It is quite clear from the table above that, relatively speaking, pre-service teacher education has been under-researched in South Africa. Ensor's in-depth study of a small group of pre-service teachers during their pre-service programme and their first year in practice in a school is a notable exception (see, for example, Ensor 2000), as is Vithal's study of the crafting of a socio-cultural and political approach to mathematics education in teacher education and again with a small group of pre-service teachers (see, for example, Vithal 2001). Naidoo's chapter in this book thus makes a significant contribution, for not only does it report on research on pre-service primary teacher education, but it does so in the context of rural KwaZulu-Natal, and a college of education structured by apartheid education and fundamental pedagogics.

What happened to action research and research as teacher education?

As the table above reflects, action research by teachers, and so *research as teacher education*, is present in the first years of SAARMSE, and then disappears. There were relatively few research papers overall in the first two years of SAARMSE. It is, nevertheless, significant that in 1993, three of the five papers related to teacher education concerned action research, research in and for practice. By 1997, however, if such research continued in the field, it was no longer reported and discussed at SAARMSE. It would be fruitful for the community to reflect on this disappearance and on whether and how it connects with a push to impact studies on the one hand, and on the other hand a diminished focus on critical theory (a framework in which much action research became rooted).

Where is research on policy and systems in mathematics teacher education?

A final comment on noticeable trends over ten years of SAARMSTE relates to policy and large-scale or systems research. In the proceedings of the first meeting of SAARMSE in 1992 and the first conference following in 1993, or what we can refer to as our early years and the setting up of an agenda for SAARMSE, there were a number of papers and reports on workshops related to priorities for research in mathematics and science education in South Africa. Teacher education features in that agenda, though rather broadly. But it is interesting to note the kinds of questions raised about teacher education at that time. In particular, in a plenary address in 1992, Treagust (1992) discussed an agenda for research, and the opportunities, options and obligations we faced, one of which was the shift emerging at that time (evident in both the USA and Australia) towards greater articulation of what counted as competencies in teaching and hence possible prescriptions for curricula in teacher education, and certification processes. Implied was the opportunity for research on these policies and pending system-wide changes. The working group on teacher education at the 1992 conference identified five research areas that warranted attention, included in which was the effectiveness of preservice teacher education. In addition, and already at that time, the factors contributing to low enrolment of well-qualified students in colleges of educa-

tion were identified for our research agenda. That we have not taken up challenges for research of this kind is an important area for reflection and action.

Issues of theoretical orientations and research methodologies

As I mentioned earlier, the framework that helps to see the 'what' in mathematics teacher education research obscures the 'how'. The numbers in the table above limit what is seen. They cannot tell us (in the form they have taken) who is doing this research or where, and these are both important for an understanding of what knowledge is being produced. Moreover, these numbers do not provide any means for interpreting the rigour of the research and thus the actual value of the reports, or their orientations.

With this limitation in mind, I nevertheless take the step of making some comments on these invisible, out-of-focus aspects of our research in the field of mathematics teacher education. Firstly, and this is visible, the research we are doing is by and large restricted to small case studies. More often that not, the research is focused on a teacher education programme in which the authors/teacher educators are themselves involved. There are benefits and constraints in this. The benefits relate to these insider accounts and the possibilities for grounded, rich descriptions (though often the papers in the proceedings are too short to present these adequately). But the shortcomings begin to emerge over time and we now face a situation where there is little that engages with the wider system through research. Our attention to the complexities of practice, and the resulting preponderance of small, rich case studies, might help us to understand why there has been a push from the political arena for large-scale studies. Vithal and Volmink (this volume) point out that as long as TIMSS remains the only large-scale study in our midst, it will continue to frame public debate in mathematics education. What does this mean for us as a community? How might we embrace the challenge, in the field of teacher education in particular, for studies that have a wider empirical base?

Secondly, while this is not visible in the table, a glance through any one set of SAARMSTE proceedings reveals that in a number of papers, the theoretical orientation (and so too the methodology) of the research study is underdescribed. This raises the question of whether the research itself is theoretically informed. Related to this, again across many papers, is a similar underdescription of the analytic tools and frames used to analyse data and so make

knowledge claims. What does it mean for a community that its methodologies and analytic frames are, in many cases, not being made visible in the papers in the proceedings of its major conference?[7] It remains unknown whether the wider research projects themselves suffer in this way, or whether this phenomenon is a function of the space limitations for a paper in conference proceedings. Nevertheless, what is pointed to here is a challenge for teacher education research that has been noted in South Africa (eg. Adler 2001) and elsewhere (eg. Wilson & Berne 1999): evidencing claims about the effects of teacher education, and about teacher learning, particularly in and through rich qualitative studies of practice, is no straightforward matter. There is much work to be done here if the research and its outcomes are to be valued.

Thirdly, an interesting phenomenon emerges in 2000 and 2001 and this is pointed to in the column on research on teacher education in the table above. Three of the papers in the 2000 proceedings in the field of teacher education and one in 2001 are discussions of the research process itself. They include the ethical issues of research 'with and on teachers' (Setati 2000), issues of validity in collaborative research (Vithal 2000), and the kinds of instruments that might better reveal teacher practices and enable claims about impact on teachers' learning and/or the mathematical learning of their pupils (Ensor 2000; Adler 2001). Together these reflect a growing and developing field paying increasing attention to the rigour of its research, and by implication to the validity of its claims.

Conclusions and comment on following chapters

The framework I have brought to bear on research related to mathematics teacher education as reflected in SAARMSTE proceedings has been illuminating, pointing to areas of focus and growth, and how we have come to constitute our field. The review has also brought into focus that which appears absent in our work. One way to describe our work here is as a predominantly responsive domain, influenced heavily since 1996 by the demands of curriculum reform. We have seen action research disappear from focus, and a concern with the mathematical preparation and development of teachers come into focus. We can see our growth in relation to case studies and rich descriptions of practice, and at the same time an absence of policy and system-wide research.

And there is much that resonates here with the implications I drew out earlier from the broad brush depiction of the international field. In addition to identifying the need for research at the level of policy and systems, the black box of the actual practice of teacher education needs opening up. A critical element that has emerged here is a growing acknowledgement that there is specificity in the mathematical work that teachers do. There is an urgent need for a greater understanding of these mathematical demands of teaching across wide-ranging classroom contexts, so as to be able to inform (and then examine, too) the mathematical curricula offered to teachers as they prepare and continue learning to teach.

At the same time, we need to continue to work productively with the gap between theoretical and practical knowledge of teaching, between teacher educators and teachers as agents in the field of mathematics teaching, and between research and practice. These tensions in teacher education as a complex site of research and practice persist. It is perhaps fruitful to talk of them as the practice, as constitutive of and constituted by the field. From this perspective, research in the context of and on teacher education will necessarily remain a core concern.

Much lies ahead and the three chapters that follow in this volume provide diverse theoretical and empirical insights into the field. In her description and critique of a case of pre-service mathematics teacher education, Anandhavelli Naidoo tells a story of novice mathematics teachers emerging from a college of education to teach in rural schools in South Africa. The study from which she draws is one of a small number that focus on pre-service mathematics teacher education in colleges of education, and provides illumination of the institutional culture in which most practising primary teachers in South Africa received their initial training, and of its ongoing effects. She describes how the philosophy of fundamental pedagogics that pervaded these institutions blended with notions of constructivism to produce peculiar and troubling practices in mathematics classrooms. Naidoo uses her study to pose significant challenges for the future preparation of mathematics teachers, where the implementation of the ideals of Curriculum 2005 requires an independent teacher, one capable of critical thinking in mathematics and of engendering this in her learners.

These challenges stand in direct contrast to (but not in conflict with) the dilemmas of designing in-service programmes described and discussed by

Mellony Graven in the chapter that follows. Again through a case study of a particular in-service programme, Graven is able to theorise teacher learning as an interweaving of changing identity, community, meaning, practice and confidence. It is this theoretical backdrop that gives meaning to and enables a teasing out of design dilemmas that ensue for any programme, no matter where. How long? Who should participate? Where is the programme located? How is subject knowledge attended to? These are all design dimensions of teacher education that present particular local challenges. For if we have learned anything in the complex arena of educational practice, it is that no matter how desirable it is for there to be overarching models and panaceas of 'what works' or 'best practice', there will be no decontextualised notions, models or lists of requisite knowledge and skills. Graven illuminates the inevitable tensions present in teacher education, an appreciation of which can enable informed and thoughtful interventions.

Chris Breen pushes further on the notion of complexity, challenging all in teacher education with a claim that most approaches and related studies see the complicated rather than the complex, and so only a part and never the whole. He does this with a more provocative challenge: whose business is teacher education?

Together these three chapters provide a brief look back at conditions and research related to pre-service and in-service mathematics teacher education in South Africa, and build on this with particular orientations and/or studies. Through them we see that issues of change and supporting change, however contentious the notion of change, are the business of teacher education and so too of research. Each raises questions for policy, research and practice specific to their focus, and I will not pre-empt these any further.

Notes

1 Mathematics teacher education is typically restricted to the domains of primary and secondary education. At these levels, teachers are required to have professional qualifications and are formally trained. Of course, mathematics is taught in tertiary institutions, and the teaching and learning of advanced mathematics is an object of empirical and theoretical inquiry, yet no formal training is required. There is an assumption that those in university mathematics departments are by the nature of their mathematical expertise, able to teach. This issue is beyond the scope of this

chapter, but it is worth signalling here why and how we come to focus on primary and secondary education in a discussion of teacher education.

2 The organisation's name, originally the Southern African Association for Research in Mathematics and Science Education (SAARMSE), changed in 2001 to include the word 'Technology'.

3 See Lerman, Xu & Tsatsaroni (2003) and Tsatsaroni, Lerman & Xu (2003), and their research into the production of the mathematics education community. In these papers the authors describe the analytic tool they have developed to analyse central publications in the field of mathematics education and then use it to reveal how our community has come to constitute itself. Particularly interesting is the dominant academic identity of teacher educator-researcher that has produced and has been produced by this wider international community of practice.

4 See Boero, Dapueto & Parenti (1996); Comiti & Ball (1996); Cooney & Krainer (1996) and Crawford & Adler (1996).

5 See Stephens (2003); Cooney & Wiegel (2003); Jaworski & Gellert (2003) and Zaslavsky, Chapman & Leikin (2003).

6 Together with colleagues and students, and as part of the work of the survey panel for ICME-10, I have been doing a survey of teacher education research reported in PME proceedings over the past four years, and a similar limitation has factored into this work. The eight-page limitation of PME papers is one reason for papers not fully illuminating the research being done, in terms of both the methodological orientations underpinning the research and the analytic frames used for data analysis.

7 As noted earlier, a similar phenomenon is present in PME proceedings.

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7 Pre-service mathematics teacher education: building a future on the legacy of apartheid's colleges of education

Anandhavelli Naidoo

Introduction

The story of mathematics education told in this chapter draws from a study of novice mathematics teachers emerging from a college of education to teach in rural schools in South Africa (Naidoo 1999). It is accurate to claim, at the outset of this chapter, that there is little research in mathematics education in South Africa that has focused on pre-service teacher education as it transpired in apartheid's colleges of education. Yet, it was in such colleges that large numbers of primary (and secondary) African teachers were 'trained' in the apartheid years.[1] As a mathematics education community, we know a great deal in general about the nature and effects of apartheid education, but little of the detail of what and how mathematics was taught and learned in these colleges, and how this training was transformed at the site of practice, which for most teachers meant an under-resourced rural primary school. This chapter – through its description of aspects of novice teachers' classroom practices, and their links to the training/education provided in a college of education – thus offers a specific contribution to the field of mathematics education in South Africa.

The research from which this chapter draws is modest. It is based on observations in the rural classrooms of novice teachers who qualified at a college of education in KwaZulu-Natal. The insights gained, however, are of significance to the development of mathematics education in South Africa. Up to the end of 2000 the majority of qualified teachers, especially in primary schools, trained at one of 104 similarly constituted colleges of education. Thus we find that most practising teachers are a product of a college of education. Apartheid's legacy, through colleges of education, is likely to be felt for some time.

In the last two years the national Department of Education in South Africa, as part of the restructuring of higher education, has closed many colleges of education and merged others with university education departments. There are multiple and complex factors driving the restructuring of higher education. Embedded in the closure and merging of colleges of education lies recognition of the poor quality that pervaded many of these institutions. The purpose of the study from which this chapter is drawn was to produce a curriculum for mathematics education with the potential to create quality teachers. The focus of this chapter is more limited. The chapter begins with a discussion of two major theoretical-ideological influences on the curriculum in colleges of education in the 1990s, fundamental pedagogics and constructivism. It then describes elements of the school context and patterns of practice of three novice teachers, and discusses how context conditions and theoretical-ideological influences work together to produce such practices. The chapter concludes with recommendations for research, policy and practice focused on this critical component of mathematics education in South Africa.

Fundamental pedagogics

Giroux (1989) notes Horkheimer's view that it is important to stare into history and to remember the suffering of the past, in order to develop an informed social practice. In line with this thesis, I felt that it was necessary to first look at what curriculum had been in existence in the past at the college in which I was working, before any suggestions for a new curriculum could be made.

During the apartheid era, Christian National Education (CNE) underpinned the South African educational system. A direct outcome of CNE was *fundamental pedagogics*, which was initiated by the Afrikaans-medium universities in South Africa. The college curriculum appeared to have fundamental pedagogics as the basis of the hidden curriculum. The relationship between fundamental pedagogics and CNE can be seen in the following statement:

> Education is a particular occurrence in accordance with accepted values and norms of the educator and eventually also of the group to which he belongs. He is engaged in accompanying the child to self-realisation, but this realisation must be in accordance with the demands of the community and in compliance with the philoso-

> phy of life of the group to which he belongs. In this way the South African child has to be educated according to Christian National principles (Viljoen & Pienaar 1977: 6).

This approach endorsed the notion of a superior ruling class and an inferior black community in South Africa. Gibson (1986) takes from the Marxist theorist, Gramsci, the concept of hegemony as domination of one state over another and extends it to include domination of one social class over others, where subordinates are controlled and manipulated to ensure the maintenance of the *status quo*. In South Africa, hegemony existed in terms of the domination of a white minority over all other racial groups. Gramsci's claim (in Gibson 1986: 53) was that 'the ruling class not only justifies and maintains its dominance, but manages to win the active consent of those over whom it rules'. There were black academics in South Africa who both accepted and postulated the tenets of fundamental pedagogics.

In his critique of fundamental pedagogics, Muir (1981) describes the relationship between pupil and teacher in fundamental pedagogics as a 'closed' relationship, where the adult's knowledge and understanding and his norms and values are transmitted to the child. The acceptable knowledge is that of the teacher; there is no contribution from the child. The child obeys the authority of the teacher, who represents the system of values of the society as a whole. This makes fundamental pedagogics anti-rational and anti-intellectual.

Fundamental pedagogics was imposed on both apartheid-constructed black universities and colleges of education, and curricula driven by this philosophy were created to serve the apartheid structures. The structure of each curriculum was prescriptive. Methods of assessment required the learners to reproduce what they had been taught, with little evidence of demands for critical thinking. To begin with, many who spoke out against the apartheid system were banned, incarcerated and intimidated. Through the broader struggle for liberation, their voices were finally heard, and changes occurred in some institutions. Black colleges, however, were by and large unable to make substantive changes to their curricula. The theoretical framework for all subjects taught was embedded in fundamental pedagogics and prescribed by the controlling body of the institution.

Fundamental pedagogics in practice in colleges of education

In trying to present a context for the curriculum, I must note that for decades, the college that is in focus in this chapter closely resembled a school. The students had to wear a college uniform. If they deviated from wearing the uniform, the staff and management reprimanded them. There was initially a daily assembly that was later changed to twice-weekly. Hymns were sung and the person conducting the assembly either read from the Bible or delivered a short sermon. If a student wanted to leave the college campus during lectures, s/he had to get written permission from the management staff. All these rules were enforced to ensure control over the students. The picture of Foucault's panopticism (1991) was put into practice by the authorities at the college. Such control was still prevalent in 1997, when democracy was a buzzword. All staff were told to report at the college at 07h30 every day, whether they had a first lecture or not. It was felt that by insisting on this arrival time, it would be possible to check that everyone was present. It is stating the obvious that such mechanisms of control are not the usual fare in teacher education institutions elsewhere as, by and large, these are situated in the tertiary and not the secondary (school) sector.

In the development of a curriculum for teacher education, one of the stakeholders to be considered is the lecturer/teacher educator. All mathematics lecturers at this college had attended schools where Christian National Education was advocated, and then went on to tertiary institutions that were created specifically for black students (which included those of African and Indian origin). At these institutions, as in the colleges of education, the philosophy of fundamental pedagogics was dominant. Most lecturers at the college proceeded from their initial training to teaching in similarly constituted high schools, before being appointed to teach at the college. At the college they were faced with teaching their students a prescribed syllabus for the mathematics content course (Department of Education and Training 1990). It should be noted that the level of prescription and regulation of syllabi and examinations was much higher at the black colleges than at the white colleges, whose curricula and examinations were externally monitored by the racially demarcated universities to which they were linked.

One of the peculiarities in the appointments of lecturers of mathematics to colleges of education was that the qualification required for such an appoint-

ment usually meant that such staff had not taught in a primary school. Yet they were, in the main, training students to teach at primary school level. Perhaps the acceptability of this situation was based on the underlying assumption that the knowledge required for teaching did not include practice-based knowledge, or knowledge of primary-level pupils or primary school conditions.

The situation relating to the didactics syllabus (Fulcrum 1992) was a little different. Here the curriculum was drawn up by a centralised group of lecturers, but colleges examined their students in this course internally. The tendency was for lecturers across colleges to follow this syllabus, exactly as it had been drawn up, whether or not they were satisfied with it. The course specified topics linked to the content in the primary school, with no mention of how children learned mathematics or why it should be taught. At the college where this study took place, lecturers seemed to accept this general syllabus as there was little evidence in the course of attempts to address the specific realities of schools where students from this college would eventually teach.

A discourse of constructivism comes to reside in the colleges

Over time, the discourses of constructivism came to reside within teacher education. Research in constructivist pedagogy by academics at some of the Afrikaans universities such as Stellenbosch University, in the dying years of apartheid during the late 1980s, was taken up in the white departments of education such as the Cape Education Department, where it grafted itself onto the framework of apartheid education. By the mid-1990s, when I embarked on my research, what was also clear was that a notion of 'constructivism' had begun to infuse the discourses of the lecturers at the college, and sat alongside the continuing influence of the philosophy of fundamental pedagogics. These dual influences were evident in the comments made by lecturers in the college, during the course of the research process.

When asked what methodologies they used, the lecturers described what they were doing as 'constructivism', which they saw as a set of practices that included opportunities for students to construct ideas, in some instances through games, in others through linking mathematics to real life situations.

> A: To teach the concepts and be able to take them out of the classroom situation you make maths a living subject. Take maths out of the classroom so that people can relate maths to a real life situation. The problem is that teachers were just handling maths inside the classroom. Every time you teach a concept they will ask you to give them an example 'Where do you get it when you get out of the classroom?' It won't be the whole concept that will go out of the classroom – maybe it will need another concept. Then you can say: 'This is an introduction to this. Once you have learnt up to this level then you will see the thing. You will apply it in this way. Then the new maths will be fun.' (Extract, Interview Teacher A)

A particular example given was of lending and saving money. From the lecturers' comments, it appeared that their emphasis through these linking activities was on the related mathematical concepts and topics, and thus on a version of applying mathematical tools to solve real life problems. A critical stance towards this 'mathematising' of society (Skovsmose 1994), however, was absent. For example, in the work on saving and lending money there was no discussion of varying interest rates and how these might or might not benefit the consumer. This is an example of how constructivism is enacted as a method, with little or no attention to critical reflection on the situation in which the mathematical ideas or techniques are embedded. Another example of constructivism as a method for mathematical learning without critical reflection is seen in the following extract. The lecturers believed that the function of this method was to locate mathematics in society and in this way to learn mathematics. Reflection on the moral implications of a mathematical application was not included in their discourse.

The excerpt below shows the lecturers' underlying ideas related to constructivism, and illustrates further that although all the lecturers mentioned constructivism, they saw it as a methodology and not a philosophy.

> I: For your methodology, you have constructivism and co-operative learning. What is your idea of constructivism?
>
> A: To involve them in groups – work together to create ideas, thereafter they report back what they have discovered in their groups. By so doing they are trained to be speakers in a maths classroom – they don't have to wait for debates – we will train

them to be public speakers so they won't have a problem with communication.

I: Is this how you put constructivism into practice?

A: Ja, they construct ideas, tell each other they accept things, ideas in their groups. I give them that opportunity to do that co-operatively. (Extract, Lesson Observation Teacher A)

Thus far in this chapter I have painted two pictures of the research context. Firstly, I described the pervasive philosophy of fundamental pedagogics, and how this has taken form in college practices. Secondly, I referred to the discourse of constructivism used by teacher educators in their descriptions of how they taught, or in reporting some of their stated beliefs about teaching. To expand this description of the context of the study, I move in the next section from the contextual background related to the college context, to the contexts of the schools of the novice teachers in this study, whom I shall name here Joseph, Simon and Lionel.

The schools

The context of the schools under observation needs to be presented before aspects of the observation are discussed. Each school will be described individually.

Joseph's school

There were no tarred roads around Joseph's school. Reaching the school required travelling along a 5 km path between rows of sugar cane. For most of this path, there was space for only one vehicle at a time. One had to go into the sugar cane plantation to allow a car to pass in the opposite direction. The pathway had been created for tractors. These 'roads' were also used by buses, and a car had to be skilfully manoeuvred to avoid losing traction. Only one bus transported teachers and pupils[2] to school in the morning and it returned for them at the end of the school day. The school had no electricity or telephones. A part of the school consisted of an incomplete building without a roof. When I enquired why the building was incomplete, I was told that there were no funds to complete it. As a result of this incomplete building, the school was short of accommodation.

My first visit was to the Grade 5 classroom. There were 76 pupils sitting three and four together at desks that were made for two pupils. The teacher said that there were supposed to be two Grade 5 classes, but because of a lack of space in the school, only one classroom was available to accommodate them. There were no charts or pictures on the walls of the classroom. It was difficult to move around because the room was full of furniture. There was a wall between this classroom and the next one, but it did not go up to the ceiling so that there was always noise coming from next door. On one occasion when I arrived at the Grade 5 classroom, the pupils seemed to be sitting quite still but there was a continual noise. The teacher reacted by saying, 'Grade 6 be quiet!' to the class next door. The noise died down.

Simon's school

Although Simon's school was 12 km from a university, the last 10 km of road was gravel. This road wound around a mountain and was badly drained. In rainy weather it developed wide furrows. Sometimes a local resident was seen placing little rocks in the furrows. It was customary to stop and give this person some money for what he was doing as he believed that he was making it easier for a car to travel on the road's surface. The school had no telephone, so arrangements for visits had to be made well in advance, and would only be possible if no other activity arose in the interim. There was electricity in this school, but with only one source: a wall plug in the principal's office. The classrooms did not have access to a power supply.

All the pupils walked to this school. In rainy weather the attendance at school was poor. Many children did not wear any shoes even though they all wore the required school uniform. When it was 'clean-up' day at the school, all the pupils worked to clean the school. This entailed cutting the grass with a slashing implement, weeding the grounds, sweeping and washing the verandas and cleaning the windows. A whole school day was used for this activity.

In Simon's classrooms, the pupils sat in groups facing each other. By turning to the side, some of them were also able to see what was being done at the chalkboard. There was always a strong focus on what was happening at the board. The groups consisted of both girls and boys. The two classes had 32 and 33 pupils respectively. One class had no charts on the wall, while the other had two charts from the previous year – one on mathematics and one

on English. There were many broken window panes. Each classroom had a cupboard built into the wall in the front, next to the board. These cupboards did not have doors. There was no table or chair for the teacher.

Lionel's school

Lionel was teaching at a secondary school in a rural area about 200 km from the city and 240 km from the college. As with Joseph's school, Lionel's school was surrounded by a sugar cane plantation. Some of the teachers lived in rooms provided by the school. Since Lionel came from an area 200 km from the school he was also given a room. The nearest village was 58 km away. There was no electricity at the school. The teachers' quarters had lights and a single plug point. The nearest telephone was in the village.

The last 15 km of road leading to the school was untarred. Tractors and small trucks used it. Yet, this road to Lionel's school was better than the roads at the other two schools that I visited, simply because it was wider. The last 8 km of the untarred road was made up of soft sand. On a rainy day the road turned into slush and it was very difficult to control a car on it. Many of the students walked long distances to get to school. In rainy weather, attendance at the school was poor. The remoteness of this school was striking.

These snapshots of three schools, and elements of their classrooms such as student numbers and surrounding resources, paint a picture characterised by poor material conditions. They highlight the immediate impact these conditions have on the way the schools function, with regard to issues like school attendance and class size. Such are the conditions in which Joseph, Simon and Lionel found themselves as they entered their first teaching job after leaving the college.

As the overarching goal of my research was to construct an appropriate curriculum for mathematics teacher education, one aspect of the research design was observation in novice teachers' classrooms. The intention was to provide an empirical base from which to understand phenomena of mathematics teaching as they took shape in these kinds of school classrooms. Grounded analysis of the observational data collected led to the description of a number of phenomena that came together to describe dominant mathematics teaching practices across the three cases in this study – i.e. of novice teachers in rural school settings. The remainder of this chapter describes and then

explains these practices, so providing a frame from which reconceptualisation of a curriculum for pre-service mathematics teacher education can proceed.

Phenomena in rural mathematics classrooms

Joseph, Simon and Lionel were each prototype novice mathematics teachers in their first year of teaching. They entered these schools immediately after completing their initial training. Through extensive data analysis, five phenomena were eventually identified as characteristic of their practices in their mathematics classrooms. Each of these teachers displayed similar patterns of practice.

The extracts and examples below illuminate these phenomena. In each of the extracts following T is used to denote the Teacher; Pn refers to a particular pupil; B refers to something written on the board.

Teacher-learner interactions are focused on generating correct answers

In the extract below, the teacher is attempting to get the students to give him their views on how to multiply by 125. He begins by reminding them of the rule for multiplying by 25, and anticipates that they will adapt this to 125. Much guessing follows, until he actually provides the answer he is looking for himself.

T: Yesterday we did 'multiplication by 25'. You said that 25 is the same as $100 \div 4$. You said that $25 = 100 \div 4$. Now let's look at this one.

T&B: 9×125 (repeats)

T: We know how to multiply with 100.

(There was no response.)

P_2: 9×200

T: Is 200 the same as 125?

(There was no response.)

P_3: 9×300

P_4: $9 \times 1\,000$

T: We are looking for a number that will be equal to 125.

Look at $25 = 100 \div 4$. Let's look at $9 \times 1\,000$. What can we do to 1 000 to give 125?

P_5: 125×5

P_6: $\frac{9 \times 25}{5}$

T: Is this equal to 125? We are multiplying by 1 000. How can you get 125?

P_7: $\frac{9 \times 1\,000}{25}$

T: No-o! If I divide 1 000 by 25 do I get 125? Now let's see if I say $9 \times 1\,000$ but here it says 9×125. Let's say I divide 1 000 by 8 what do I get?

(Extract, Lesson Observation)

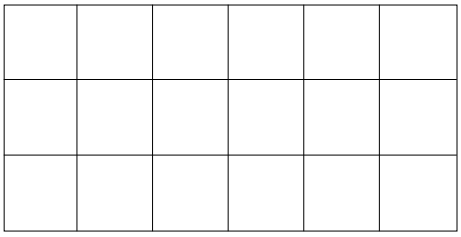
This phenomenon of pursuit of the answer is a well-known feature of traditional mathematics classroom practice (Adler 1997). In the classrooms observed in this study, there was, in addition, a tendency towards regimentation in the learning environment, with the teacher clearly in authority. In these teacher-learner interactive episodes, it was often the case that only those utterances that contained correct answers were acknowledged. It is interesting to pause and focus on what the pupils are able to offer in the kinds of interchanges exemplified and described above: little more than some guess at what the teacher intends, without it being clear what this intention is. There is little room for students to make sense of what it is they are meant to be doing or learning.

In these classes, when pupils were given work to do (exercises to complete) they were largely seen to work silently. Together these phenomena go some way to explain the reason for the existence of passive pupils who tended to accept the teacher as the authority.

Teaching produces confusion between rules and reality

In the following extract, the teacher is working with students on the calculation of areas. As he proceeds and attempts to assist students' understanding of what it is they are meant to be focused on (i.e. the amount of surface covered), he calls up an inappropriate reference to the real world, and in so doing, instead of illuminating the problem, reduces its meaning to following a set of rules.

The teacher drew the following grid for pupils, and asked them to calculate the area. As he worked with them, this is what he did:



T: How many squares are there on the long side?

P_1: 6 squares

T: How many squares are there on the short side?

P_2: 3 squares

(Extract, Lesson Observation)

Using this recognition of the form of the grid, the teacher then tried to contextualise it, creating a context in which each of the blocks was to be counted (which procedurally will provide the answer to the question of what the area of the grid is). However, the context chosen did not match the concept of area.

T: We are asked to calculate the squares in the area. If we are asked to count the people living in Mjoji we will count all the people. The people who are living here are all the squares ... the people who are living here are all these squares belonging to one area. Now we are asked to count these squares. How many of them are in the same area?

B: Area =

T: We have a long side and a short side. When we calculate the 3 squares or the people or whatever …

T&B: Area = squares in long side × squares in short side

(Extract, Lesson Observation)

In the end, the example was unhelpful, an inappropriate metaphor that obscured rather than enabled mathematical meaning. Students were left with having to accept a rule for calculating areas that was devoid of meaning and reason.

This phenomenon, of the context becoming the problem, rather than being a source of greater meaning and understanding of the use of mathematics, was widely observed. At the same time, I also observed the obverse phenomenon. This is illustrated by the example below. In both cases, and from a critical perspective, the opportunities afforded by contextual links in mathematics learning for mathematics to become a tool that can be used in real life problem-solving, and for critically reflecting on aspects of the social order, got lost.

The context of the problems gets lost in the teaching

To complete his lesson once a calculation was taught, Simon gave the pupils word problems. After teaching an algorithm like multiplication by 25 and 125, he wrote a word problem on the board. He then explained the problem in Zulu, immediately focused on the numbers in the problem and gave the operation to be used.

B: A man has 12 chickens and sells each chicken for R25. How much will he get for his chickens?

(He read the problem out in English and then explained it in Zulu.)

T: Indoda inezinkukhu ezi u12. Uma idayisa inkukhu ngayinye uR25 izothola malini kulezinkukhu zayo ezi u12. This means ...

12 chickens × R25.

B: 12 × R25

B: A girl sells 125 sweets. Each sweet costs 15c. How much will she get for her sweets?

(He repeated the question to the class in Zulu.)

T: Intombazane idayisa uswidi ongu 125. Uswidi ubiza fifteen cent umunye. Uzothola malini ngalo swidi? How many sweets?

P_1: 125

T: How much are the sweets?

P_2: 15c

T&B: 125 x 15

(Extract, Lesson Observation)

So, as with the first example, the focus is on getting an answer. Whereas the context became an intrusion and possible source of confusion in the second example presented above, in this third example it is used to introduce a problem and then immediately backgrounded.

Teaching produces mathematical contexts with conceptual flaws

When one of the teachers set out to work with parallel lines and the angles formed when cut by a transversal, he set the activity in the context of a rectangular shape, ABCD. He marked each of the angles of ABCD using the symbol for 90°, and then drew a diagonal from A to C, to produce alternate angles.

In discussion with the learners, and with a focus on alternate angles produced being equal, each angle formed by the diagonal was assigned the value of 45°. And so, a property that would only hold for the particular case of a square came to be associated with a rectangle and generalised to all alternate angles formed by parallel lines, cut by a transversal.

Mathematics teaching is about procedures rather than concepts

The episode in the extract below is drawn from a lesson on measurement in which units of measure, square millimetres, came into focus. As is clear from the extract, the interaction between the teacher and the students is on a procedure for establishing a unit. The idea of a square millimetre, and how it

functions as a unit of measure, was not dealt with. In this context it would be difficult for students to develop awareness of the actual size of a square centimetre or a square millimetre. Here, 'mm^2' was merely a calculation.

T: mm x mm?

P_1: mm.

T: You are saying that $2 \times 2 = 2$

P1: No ... equal to four.

...

T&B: $2^1 \times 2^1 = 2^{1+1} = 22$ – means two squared.

T: Any number has a small one up there. We call the one the index.
$1 + 1 = ?$

P_1: 2

T: $1 + 1$ will give you a small ^{2} which is two squared. In 3×3 it means that 3 has what on the top?

P_2: Indexes.

T&B: $3^1 \times 3^1 =$

(There was no response.)

T: What have we done with the indexes? When we multiply, we add the indexes. $1 + 1 = 2$

T&B: $3^1 \times 3^1 = 3^{1+1} = 3^2$

T: Now we had $mm^1 \times mm^1 = ?$ Remember that mm has a small ^{1}, an index.

P_2: Metres square.

T: These are millimetres. A metre is written as m. What is the answer?

P_3: Millimetre square.

T: If you multiplied m by m what will you get?

P_4: Metre.

T: Metre?

P_5: Metre square.

T: $3 \times 3 = 3^2$ – now millimetre × millimetre?

P_6: Millimetre square.

T: Millimetre square. This is our answer.

(Extract, Lesson Observation)

An overview of phenomena of practice

How can the phenomena of practice illustrated above be interpreted and explained? The brief discussions above of fundamental pedagogics on the one hand, and constructivist discourse on the other, and of the way in which these two perspectives came to co-exist in colleges of education, provides some insight here.

Across the episodes, and so across the practices in these teachers' classrooms, there was, as noted above, a tendency towards regimentation in the learning environment, with the teacher clearly in authority. Classroom interactions were dominated by a focus on getting a right answer, usually through some procedure given by the teacher. When students were left to work on exercises themselves, they also did this largely in silence. The weaving of fundamental pedagogics into the social fabric of these classroom practices is highly visible.

At the same time, however, there is evidence of teachers struggling within this dominant context, to bring in some notions of constructivism. In particular, everyday examples were drawn on in an attempt, it appears, to connect with learners' realities, and assist their meaning-making. Often, though, the context was little more than a veneer, lost or backgrounded soon after it was introduced. At times, the context worked to obscure rather than enable the meaning of the mathematics being taught.

In the larger study from which this chapter is drawn (Naidoo 1999), I described these practices as 'traditional' and argued that it was apparent that these were the pedagogic cultures into which the novice teachers had been inducted. I contrasted these with 'alternate' practices, which could then be the basis for reconceptualising a curriculum in pre-service mathematics teacher education. These contrasts are summarised in the table following.

Table 7.1 Patterns of practice

Traditional	Alternate
Imposition	Negotiation
Conveyance of meaning	Negotiation of meaning
Tripartite	Focus pattern
Product-oriented	Process-oriented

Explaining the phenomena and looking ahead

Many explanations have been advanced for why teachers engage in particular practices. One set of explanations has focused on teachers themselves – on issues of teachers' knowledge, attitudes to their socialisation, apprenticeship, life histories and identities. In terms of these explanations, analyses may be made of who the three teachers in the study discussed above are, and of the nature of their own experiences and background. Another explanatory approach has been to consider the resources and context of schooling – in relation to the present study, the poverty of this context. Simon and other teachers in similar settings of large, under-prepared, under-resourced classes engage in particular practices in order to function with competence in their schools and within their particular community of practitioners and structures of schooling, assessment and policy demands.[3] However, the focus of my research was on a third possible set of explanations relating to what student teachers experience and learn in their teacher education curricula, which must in part also account for the practices they subsequently engage in. In particular, one focus in my research was the philosophy and theories underpinning those curricula. It is these underpinning elements, and how they infuse the curriculum, that lie at the heart of what comes to be experienced in pre-service teacher education practice.

With the change of government in 1994, it became evident that fundamental pedagogics as a philosophy no longer had any role to play in education. Education in South Africa needed to take into account the inadequacies of the past. The learner needed to be emancipated to the extent of being critical of her learning. The rights of individuals were being expressed. The time for being mere recipients of the values of a higher authority was over. Teacher education needed to take its place as the focal point for changes in the education system.

The first steps made by the central government to move away from fundamental pedagogics are evident in the document drawn up in 1995 by the Committee on Teacher Education Policy (COTEP) and sent to all teacher training institutions. This document has since also been revised to accommodate further changes to the system of education. Mathematics teacher education is located within teacher education, so in order to examine developments in mathematics education, we need to consider how teacher education has changed.

The changes that are taking place at schools include the introduction of a new educational system called Outcomes-Based Education (OBE). All teaching is required to focus on a general set of critical outcomes for education. In the South African context the inequalities in society, and the transition to a democratic, non-racial, non-sexist, equitable society are to be emphasised. The fact that national education policy-makers see the need for mathematical literacy as part of the curriculum opens the doors to a form of liberatory mathematics in our country.

At this stage, a dilemma exists: how can this dream to create critical citizens through education be realized in general and in mathematics education in particular?

The initial influence on my ideas came from what the college lecturers felt should be implemented. For them the basis of their pedagogy was constructivism. The shortfall in their conception of constructivism was that it was seen as a method and not a theoretical framework from which to develop approaches to teaching. When constructivism is reduced to a methodology, it is possible to consider only what is convenient for the practice and not really to understand the thinking behind it. If constructivism is taken to mean groupwork, then this will explain why I found pupils arranged in groups in some of the classes where I observed teachers. The lecturers at the college seemed to ignore the theory of constructivism in exposing their students to the methodologies that were in line with constructivism, whilst the student teachers seemed to ignore these methodologies when implementing constructivism. They just maintained the physical appearance of pupils sitting in groups in the classroom.

My interpretation is that constructivism is a philosophical perspective on knowledge and learning. When looking at the origins of constructivism in

order to place it in terms of a theory that can be espoused in pre-service teacher training, one has to consider both radical constructivism (von Glasersfeld 1987) and socio-constructivism. Debates on the descriptions of these two philosophical perspectives and their inter-relation (or disjuncture) have abounded in mathematics education research, and lie beyond the scope of this chapter. Interested readers are referred in particular to Lerman (1996) and the debate that followed this paper in subsequent issues of the *Journal for Research in Mathematics Education*.

As students, the novice teachers had not been made aware that a particular perspective was being adopted. There was no focus on why this perspective was chosen over others and how best to implement it. It became clear that no time was spent reflecting on what was being done. It appears that the lecturers have not put the constructivist approach fully into practice, where the students' prior experience is considered. The students were not asked to construct the most suitable approach that could be used by teachers. Their encounter with constructivism was incidental.

When I embarked on my research, constructivist philosophy had become woven into the practices of South African mathematics educators, and in particular into motivations for curriculum reform practices in foundation phase classes. However, the social and political contexts into which these practices were inserted were not considered as significant to the practice. This was why it was possible to implement a constructivist approach to mathematics within the apartheid system. The question that arose in my study, and in the context of post-apartheid South Africa, was whether constructivism as a philosophy of knowledge and learning could accommodate the concerns of Critical Mathematics Education (Skovsmose 1994). Perhaps, then, the product, critical constructivism (Taylor 1996), could lead to more appropriate curricula and classroom practices in South Africa.

Taylor (1996) refers to the critical theory of Habermas and focuses on the communication actions of the teachers and students, where knowledge is mediated by social experience. In her critique of constructivism, Zevenbergen (1996) finds fault with the way constructivism was used within the apartheid structures in South Africa in the 1980s. By focusing on the individual's construction of meaning in mathematics, constructivism tends to ignore the socio-political context in which learning occurs. It does not take account of

any aspects of the social and cultural differences of a group of learners. As Zevenbergen (1996: 100) observes:

> A constructivist approach to understanding how students come to make meaning within the mathematics classroom, tends to have focused predominantly on the cognitive aspect of learning, although there is an increasing awareness of the role of social interaction in the learning process ...

Taylor (1996) argues that a curriculum infused by critical constructivism could see teachers engaging their pupils in critical discourse that includes aspects of social inquiry. The communication that occurs is aimed at mutual understanding and is open and critical. If teachers are to enact such negotiation, they need to develop their own skills of critical self-reflection to encourage these in their pupils. In the focus group interview that formed part of the wider study from which this chapter is drawn, the 'Lecturers' hopes for the future' included considering their student teachers' needs. This could be extended to include the student teachers' interests. Critical reflection can occur only if what is being discussed is of interest to the learners. These college lecturers suggested a focus on '*independent thinking*' and developing '*critical minds*'. What this suggests is that the ideas encompassed in critical constructivism should therefore be included in a revised pre-service mathematics teacher education curriculum.

Conclusion

When one recalls the struggle during the apartheid era one remembers the call for *liberation first then education*: this took the struggle out of the classroom. It was believed that 'people's mathematics' would bring the struggle into the classroom. This approach focused on *emancipating the learner from* the shackles of apartheid. Now the focus in the country has moved towards *emancipating the learner to* become a critical citizen through Outcomes-Based Education.

In order to create critical learners we first have to develop critical teachers. Pre-service courses in mathematics education need to place a greater emphasis on the teacher as reflective practitioner. The theory of constructivism advocates negotiation. If negotiation is seen as a necessary stage on the

journey to democracy, then constructivism can be seen as supportive of the development of democracy. While constructivism also regards reflection as a priority, constructivism on its own is not conducive to emancipation. Although Taylor does not overtly focus on emancipation as an aspect of critical constructivism, I propose that we consider emancipation as an integral part of critical constructivism.

With teacher education becoming the prerogative of higher education, and with field experience in teacher education being labour-intensive and thus expensive, there is a serious possibility that future pre-service mathematics teachers will have less than the desired amount of contact with practitioner experts in the field, during their pre-service study. Pre-service teachers might well end up with studies in mathematics offered by mainstream mathematics departments, and with limited time focused on pedagogic knowledge and pedagogic content knowledge. It becomes imperative that these more limited opportunities for engaging with pedagogic knowledge and pedagogic content knowledge should focus on the teacher and what he or she is about to face in the real world of classroom practice.

If one reflects on teacher education policy, it is possible to detect a disjuncture between the desire for critical thinking to be promoted in schools, and the policies, opportunities and structures that support teacher education. The jury is out on the closure of colleges of education, and on the restructuring of all teacher education into university contexts. While the motivations relating to quality control are important, the realities of all future teachers being able to access full degree study are open to question.

Finally, even within its modest scope, this chapter points to the importance of research in pre-service teacher education in mathematics, in educational contexts where large numbers of teachers are being prepared for their work.

Notes

1 See Welsch (2002) for a history of teacher education in South Africa, and a discussion of the emergence of these colleges in homeland areas during the apartheid era and their recent closure as part of the restructuring of higher education in post-apartheid South Africa.

2 With the introduction of Curriculum 2005 the generic term 'learners' has replaced previously used terms such as 'pupils' and 'students'. However in this chapter 'pupils' is retained as a term referring to school learners, and 'students' is used to refer to learners at teacher training colleges, in order to distinguish between these two groups. 'Learners' is used for more general references to all groups of pupils, students, etc.

3 See Adler and Reed (2002) for a detailed study of teacher education, and of where the explanations are located in relation to interactions between teachers and their work contexts.

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8 Dilemmas in the design of mathematics INSET

Mellony Graven

Introduction

In reviewing SAARMSE/SAARMSTE proceedings from 1999 to 2001 it became clear that teacher education maintains an important position in the interest of SAARMSE/SAARMSTE participants. This is evident in some plenary papers that have focused explicitly on teacher development (eg. Breen 1999b) as well as in the range and number of papers presented on teacher education. Research relating to teacher development tends to focus on the following: challenges for teacher development (eg. Breen 1999b; Brodie 1999, 2000), teacher beliefs (eg. Newstead 1999; Hobden 2000; Stoker 2000), teacher knowledge (-in-practice) (eg. Nyabanyaba 1999; Adler 2002b) and teacher change in relation to INSET (eg. Brodie 1999; Graven 2000a; Spannenberg 2000).

The research reveals that teacher education (or teacher development) is a very complex matter indeed. Furthermore research and ongoing reflections by in-service practitioners indicate that in many cases teacher 'take-up' of practices promoted by in-service courses is low (see also Adler 2002a). For these reasons I believe that the articulation and theorisation of the dilemmas and tensions we face in the design of in-service programmes is an important and necessary part of our praxis as teacher educators. I elaborate on this belief in this chapter in relation to the case study of one mathematical INSET project, namely the Programme for Leader Educators in Senior-phase Mathematics Education (PLESME). I believe further that this theorisation will result in increased dialogue between practitioners in this field, and hopefully in increased creativity and sensitivity in finding ways to hold these dilemmas in productive dynamic tension.

PLESME was a long-term (two-and-a-half-year) in-service education and training (INSET) project based at the Centre for Research and Development

in Mathematics, Science and Technology Education (RADMASTE), at 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 of sustaining teacher learning beyond the life span of the project. 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, etc. PLESME formed the empirical field for a two-year research project that investigated the nature of mathematics teacher learning within an INSET community of practice. The project (and its related research) worked with sixteen senior-phase mathematics teachers from eight schools in Soweto and Eldorado Park.

In PLESME I wore two hats. Firstly I was the co-ordinator of PLESME and secondly I was a researcher, conducting research on the nature of mathematics teacher learning in relation to INSET within the context of rapid curriculum change. I was expecting some tension to emerge in relation to my role as an 'INSET co-ordinator' and my role as 'researcher', primarily because I had struggled to distinguish these roles clearly in the research. Instead I discovered a 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. Working closely with teachers in PLESME helped give form to the research and the research process and enabled me to work with more sensitivity and reactivity in PLESME. My own learning in terms of becoming a more experienced 'INSET provider' was maximised by the ongoing reflection, which was stimulated by the research.

The broader research drew primarily on Lave and Wenger's (1991) and Wenger's (1998) social practice perspective of learning. The works of Lave and Wenger (1991) and Wenger (1998) are increasingly being drawn on to describe and explain student and teacher learning in the field of mathematics education. (See for example, Adler 1996, 1998, 2001; Boaler 1997, 1999; Boaler

& Greeno 2001; Lerman 2000; Santos & Matos 1998; Stein & Brown 1997; Watson 1998). Furthermore, some mathematics educators are increasingly arguing for the usefulness of their work for analysing mathematics *teacher* education (Adler 1998; Lerman 2001).

According to Lave and Wenger (1991), learning is located in the process of co-participation and not in the heads of individuals; it is 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. Lave and Wenger prioritise the importance of *participation in the practices of a community* and *identity* as primary features of learning:

> [Learning] implies becoming a full participant, a member, a kind of person… (1991: 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. (1991: 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. (1991: 98)

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

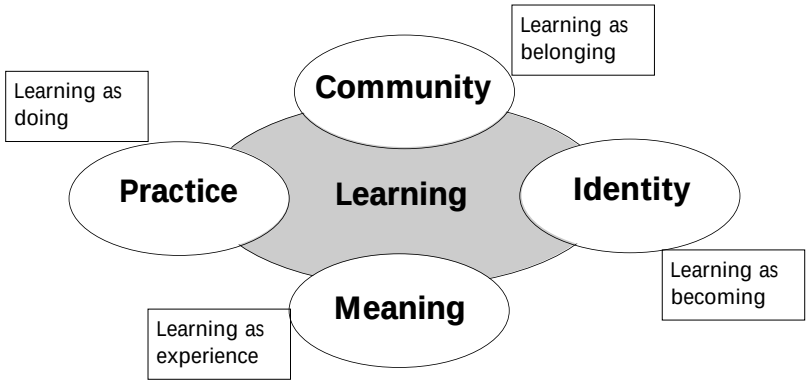
> To become a full member of a community of practice requires access to a wide range of ongoing activity, old-timers, and other members of the community; and to information, resources, and opportunities for participation. (1991: 101)

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

Wenger (1998) identifies four components of learning that together provide a structuring framework for a social theory of learning. Wenger (1998: 5)

summarises this framework of components that are 'deeply interconnected and mutually defining' in the following diagram:

Figure 8.1 Components of a social theory of learning: an initial inventory



He 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' (1998: 5). It was the ability of these four components 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, that proved particularly useful as a structuring device for describing and explaining teacher learning in PLESME.

Drawing on this framework, two primary assumptions informed the design of both the in-service project and the research: a) teacher learning would be enhanced by stimulating participation within a community of practice where members of the community of practice would provide support for teacher learning; b) implementation of the new curriculum would involve changes in teacher roles and teachers' 'ways of being' (identities).

In interviews with teachers about their learning within the INSET context, it became evident that teachers themselves saw their learning as a process of

developing new identities. This quote from a participating teacher, six months into the INSET, captures this: 'You know before I always used to introduce myself as the music teacher, now I introduce myself as the maths teacher' (Interview, Beatrice, July 1999).

Since the INSET was a long-term process 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. 'Practice' and 'Meaning' are learning components that are the focus of most pre-service and in-service teacher education. Teacher education focuses on developing teacher knowledge and practice in relation to a learning area and a particular curriculum framework. Clearly these are crucial components of teacher education and learning and indeed they were central components in the design of PLESME. However, the components of 'Community' and 'Identity' are equally important in teacher education/learning within mathematics INSET (see Graven 2002) but these often tend to be overlooked in the design and implementation of INSET. Prioritising the components of community and identity will have implications for the design of INSET. In this chapter I discuss the theorisation of five dilemmas in the design of INSET and the implications of these dilemmas for INSET that sees the components of 'Community' and 'Identity' as central components that enable and facilitate teacher learning.

The dilemmas that I discuss emerged in PLESME and are therefore exemplified in the case of this project. These dilemmas are, however, in no way limited to PLESME (Adler 2002a) – they are inherent and need to be managed in the design of all INSET projects. I believe that the articulation of these dilemmas provides a useful tool for conscious reflection and working practice (Adler 2001) in the design of INSET projects in general.

It is beyond the scope of this chapter to discuss the methodology and the findings of the broader research project from which this chapter is derived (for this see Graven 2002). Suffice it to say here, that the broader research project employed a qualitative ethnographic approach in which I adopted the position of observer participant. Methods of data collection included journal entries, teacher interviews, teacher questionnaires, classroom observations and field notes over a two-and-a-half-year period. In this chapter I focus on the findings of the broader research that relate to the theorisation of dilemmas that emerged within the design of the INSET project that formed the empirical field for the research.

Five key dilemmas that emerged in the design of PLESME

The dilemmas discussed here 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 I confronted in relation to these design features and provide some rationale, which is rooted in a social practice perspective that highlights community and identity as central learning components, for the decisions I made in the case of PLESME. The five key dilemmas are: A) the dilemma of duration and scale; B) the dilemma of site; C) the dilemma of who; D) the dilemma of focus (mathematics versus methods); and E) the dilemma of ethos (teacher change or teacher learning). I will deal with each of these separately.

A. The dilemma of duration and scale

Why long-term INSET?

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 situation. It is widely accepted that current curriculum initiatives in South Africa demand that attention be given to teacher support, especially in the fields 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 emphasise the construction of mathematics as a human activity in an attempt to understand the world and emphasise a competency-based model of education. Teacher roles have been redesigned (Department of Education 2000) 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 Department of Education (DoE) 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 would cascade the knowledge to district officials who in turn would 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).

A major influence on the design of PLESME as a long-term, classroom-focused project came from my own experiences of working on short-term, workshop-based INSET projects with teachers. In earlier research (Graven 1997, 1998), I examined the 'impact' of a limited number of workshops (6–8) and classroom visits (one 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. Furthermore, the intervention was too short-term to enable a well-functioning community of practice to develop and therefore there was an absence of a supportive structure that would ensure the sustainability of any gains that had been made. 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 for INSET rather than being compelled to participate, INSET in which there was sufficiently regular and ongoing activity to enable the formation of a community of practice in which teachers could form 'a history of mutual engagement' and 'strong bonds of communal

competence' (Wenger 1998: 214). The above experiences led me to the development of PLESME as a long-term, intensive and classroom-focused project. This development, in turn, impacted on the scale of PLESME.

Classroom-focused INSET implies a need to support teachers in their classroom practice, resulting in a highly labour-intensive design that is difficult to expand to a large number of teachers without a large increase in resources (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 large-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 it is being increasingly acknowledged in policy and strategy documents. Kahn (2000: 18) captures this tension as follows: '[D]ispersed low unit cost intervention may not work, but concentrated high cost intervention may succeed. How then to compare costs?'

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 will 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. These leader roles therefore extended beyond the PLESME community of practice to various overlapping communities. 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 learned in the same way but rather were expected to take on a wide range of leadership roles according to their strengths and contexts.

B. 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 (eg. the University of the Witwatersrand, 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 projects 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 will 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 were 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, etc. was 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.

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 and Adajian (1997: 194) 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.

They operationalise their conception of mathematics teachers' professional communities in terms of 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 which emerged from work in PLESME.

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. Wenger (1998: 214) defines a community of practice as follows:

> On the one hand, a community of practice is a living context that can give newcomers access to competence and also invite 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 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.

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 (Department of Education 1997). 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 field trips 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, and later I 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 (comprising individuals from schools and institutions) that is practice-based, classroom-focused, intervention-located (and networked) within the broader professional practice of mathematics education.

C. The dilemma of who

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 which schools to work with, the project proposal was clearly aimed at supporting previously disadvantaged communities. The PLESME proposal reflected the commitment of the donors, the commitment of the 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 providing 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 resources) to previously disadvantaged groups, existing inequalities are likely to remain unchanged.

Similarly, the race of the INSET provider or researcher can be problematised. In response to an absence of debate relating to the possible abuse of black teachers at the hands of white researchers, debates have recently begun emerging as to ethical concerns relating to the race of the researchers and the researched (see Mahlomaholo & Matobaka 1999). Various questions emerge from such debates, for example: Do you have to be black to conduct research

or INSET with black teachers? What constitutes racial sensitivity on the part of researchers and INSET providers? These are important and difficult questions. It is beyond the scope of this chapter to deal with them in detail; suffice it to say that a serious and important challenge exists to move research and development work in education to include white, so-called coloured and Indian teachers.

In PLESME I chose to work with teachers from previously disadvantaged communities, including schools in black and so-called coloured areas. While both these groups of schools had 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 their research and that they consciously reflect on ethical concerns relating to their practice. Thus the 'who' 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 in the appropriate phase) 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 wanted to maximise access and form a supportive community of practice among the mathematics teachers from participating schools; it therefore accepted all senior phase 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 who needed 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 with the opportunity to do so.

Furthermore, I would like to argue that the development of stronger identities as professional mathematics teachers works to retain teachers within the

profession. This is best captured in the case study of Sam, one of the PLESME teachers. 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. Sam expressed his intention to remain in teaching for approximately five years and then move into a career in computers. During the two-year period of his PLESME work Sam's identity as a competent 'mathematics teacher' strengthened. In a questionnaire which was administered a year and a half after the commencement of PLESME Sam provided evidence of his strengthened identity as a confident and competent mathematics teacher who was 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. (Questionnaire, Sam, July 2000)

The excerpt above indicates the projection of Sam's identity as a mathematics teacher that is beyond present time. According to Wenger (1998), identities, as trajectories, incorporate the past and future while negotiating the present. Sam's utterances indicate a clear mathematical trajectory that prioritises mathematics learning in the present and the future. Sam's trajectory involves continuing to establish himself as a leader in the field through further studies, ongoing participation and presentations at mathematics education conferences and helping fellow teachers. 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. (Interview, Sam, November 2000)

Sam's story indicates the relationship between his strengthened identity as a mathematics teacher and his projection of this identity beyond the present and into the future.

D. The dilemma of focus – mathematics versus methods

Currently in South Africa 50% 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 they taught mathematics because no one else wanted to teach it and since they had studied some mathematics at school they were the most qualified to teach it.

Thus many of the teachers did not identify themselves as mathematics teachers. For example, 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, Barry, October 1999). The challenge for PLESME was therefore to help teachers to 'become' mathematics teachers in terms of both knowledge and identity. 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.

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 (Adler et al 1999; Brodie, Lelliot & Davis 2002). And indeed the *Report of the Review Committee on Curriculum 2005* (Chisholm et al. 2000) warns of the watering down of mathematical content in the interpretation of the learning area MLMMS (Mathematical Literacy, Mathematics and Mathematical Sciences). There is a clear danger in the implementation of the new curricu-

lum for mathematics teachers to adopt the pedagogical forms without necessarily assisting learners to develop mathematical meaning. In an attempt to avoid this dichotomy, PLESME focused on the development of mathematical meaning and pedagogical forms simultaneously. 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. This implied a need to focus on the development of stronger mathematical competences, especially for those teachers of mathematics with weak mathematical histories. Thus a focus of many PLESME activities was to develop and deepen mathematical competence in a way that enabled teachers to foreground mathematical goals in their teaching and to develop stronger identities as mathematics teachers.

Within Wenger's framework this involved providing teachers with access to a wide range of mathematics teaching resources, including: curriculum documentation, mathematics texts, mathematical practices, mathematics pedagogical content knowledge, mathematics discussion, reflection on mathematics teaching practices, participation in mathematics teaching conferences, engagement with mathematics district workers, and so forth. 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, graphs, etc.). In some workshops teachers explored various outcomes such as those involving mathematics as it is embedded in various social, political, economic and cultural contexts. In other workshops teachers debated new curriculum methodologies such as learner-centred practice, groupwork, continuous assessment, etc., 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.

Elsewhere (see Graven 2000b) I have outlined and elaborated four different orientations towards mathematics that can be identified within the new South

African mathematics curriculum and have related these to four corresponding roles for teachers. These orientations are that the teacher's role is to: prepare learners for critical democratic citizenship (i.e. the teacher becomes a critical analyser of the way mathematics is used socially, politically and economically and supports learners to do the same); develop local curriculum and apply mathematics in everyday life; be an exemplar 'mathematician' and apprentice learners into ways of investigating mathematics; serve as a 'custodian' of mathematical knowledge or a deliverer of mathematical conventions (definitions, algorithms, etc.) important for further mathematics studies (the teacher is a 'conveyor' of the practices of the broader community of mathematics teachers).

These new roles have implications for teacher identities. However, as Wenger (1998) points out, while national education departments can design roles, they cannot design the identities of teachers. The implication of this for INSET is that teacher development is far more complex than simply retraining teachers, and therefore ways must be found to support teachers in developing new professional identities. Harley and Parker (1999) conclude that to implement curriculum changes 'teachers may well need first to shift their own identities, their understanding of who they are and how they relate to others' (197). The broader PLESME research study (Graven 2002) analyses teacher learning within mathematics INSET in terms of the relationship between the new mathematics roles, the generic roles for educators as outlined in the Norms and Standards Document for Educators (Department of Education 2000) and the development of teacher identities, and highlights the contradictory demands the curriculum makes in relation to these roles for teachers and for mathematics teachers in particular. Thus, I argue that especially at a time of curriculum change, where new roles are outlined for teachers, it is important that teachers have access to participation in supportive communities of practice where they can shape new identities for themselves within the profession of teaching.

E. The dilemma of ethos: radical teacher change or teacher 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. That is, 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 will 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 (especially experienced 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 (1999a: 42) 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'.

I earnestly wanted to move away from this deficit 'fix it' approach but was stuck with the dilemma that, if I thought teachers did not need to change, why did I want to 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 workshop to show snippets of the teachers' videos in order 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, overlooks the importance of drawing on existing knowledge and experiences as an important learning resource, and contradicts the philosophy of life-long learning.

Ensor (2000) writes that 'the task of many inservice and preservice providers is to make available to teachers this privileged repertoire, this particular embodiment of "best practice"' (118). (This should not imply that Ensor promotes the view that the task of in-service providers *should* be to do this but rather that in practice many do this without reflecting upon what it is that they make available.) My picture of 'best practice' was, however, not clear or stable, and I believed that 'best practice' was dependent on the educational and mathematical histories of teachers (in the broadest sense) and their classroom contexts. 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 it to them. This is not to say that I did not have my *own preferences or principles of selection* that influenced the nature of the workshops, the methodologies that I drew on for workshops, the comments I made on teachers' lessons and the nature of PLESME activities. Of course, the design of all teacher education programmes will be influenced by the views of the designers as to what constitutes appropriate practice, but this is not necessarily stable across time, contexts and people and the complexity of one's 'implicit frameworks' can be extremely difficult to articulate. 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'.

In the broader PLESME study (Graven 2002) I explore the relationship between PLESME's approach to INSET, as the stimulation of life-long learning, and teachers' developing confidence. The approach enabled teachers to reconstitute their identities from 'teachers of mathematics with limited mathematics training' to 'mathematics teachers with the confidence to be life-long learners within their profession'. These new identities are captured by the following utterances of teachers at the end of the two-year INSET:

> I was confident enough to invite Barry (teacher in PLESME) to do this part of a lesson and the kids will enjoy it … We are usually

> afraid to do this because it means admitting weakness. Confidence allows me not to have to know everything. (Interview, Ivan, November 2000)
>
> 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. (Interview, Karl, November 2000)
>
> And also knowing that if it doesn't work for this lesson I can change my method and try something else, it's not a matter of do it or die kind of thing. (Interview, Delia, November 2000)

These quotations reveal that teachers came to view life-long learning as an integral part of being a professional mathematics teacher irrespective of one's level of formal education. Thus teachers challenged the 'all-knowing' construction of 'a professional teacher'. This new construction supported teachers in strengthening their identities as mathematics teachers despite the limitations of their pre-service studies. I emphasise the limitations in their *pre-service* studies since these limitations were, to an extent, addressed through their two-year participation in PLESME. Teachers expressed confidence in the acceptance that indeed one cannot know everything but one can become a life-long learner within the profession of mathematics teaching. This new approach to learning was both a result of confidence, and provided teachers with increased confidence. I argue that since INSET is always limited in relation to the time and resources available to the INSET providers, the most important outcome of INSET should be enabling teachers to adopt identities as life-long learners that endure far beyond the scope and life span of the INSET.

Some conclusions and tentative recommendations

I have argued that the way in which I chose to resolve various dilemmas in the design of PLESME was influenced by a perspective that prioritised community and identity in the learning of teachers. This should not, however, imply that this is the only appropriate path for all INSET programmes. Rather, I argue that those involved in INSET should reflect on the implications of the decisions they take in relation to the dilemmas articulated in this chapter.

However, the fact that the dilemmas discussed here have been exemplified by the PLESME INSET programme, in which I participated as both researcher and practitioner, leads me to offer some tentative recommendations for the design of future INSET programmes. It is to these that I now turn.

- INSET activities should be located within a community of practice that enhances teacher participation with overlapping professional communities.
  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. In addition, the broader study provides a detailed analysis of various tensions inherent in the implementation of the new curriculum (and in particular the new mathematics curriculum) and describes the experiences of the teachers in relation to these tensions. This analysis illustrates 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.
- Longer-term INSET is preferable to short-term INSET.
  PLESME worked with teachers over a two-year period. The broader 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 broader study argues 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 communi-

ties, and continued to actively embrace this role after PLESME ceased. In this respect I suggest that the relatively high cost of interventions such as PLESME is justified.

- Mathematics INSET activities should support participants to develop stronger identities as *professional mathematics* teachers by foregrounding the development of mathematical competence.
  As discussed above, 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 teachers' '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.

  The broader research from which this chapter has emerged revealed that all the teachers in PLESME developed stronger identities as professional, confident and competent *mathematics* teachers over the period of participation in the programme. The changes in teacher identities cohered with their school communities' perceptions of them as 'expert' *mathematics* teachers and as knowledgeable educators with a lot to offer education in general.

- INSET activities should focus on creating a positive ethos that stimulates life-long teacher learning rather than emphasising the need for radical change.
  This chapter has described the nature of PLESME and has highlighted the importance of a shift in the approach to teacher learning from immediate/ urgent radical change to stimulating life-long learning for learners who are already practising professionals. There is substantial evidence in the broader 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 undermining and unsuccessful.

The broader study 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, in relation to their 'being heard', and in relation to their being considered professionals. INSET interventions must acknowledge that their learners are special in the sense that they are already practising
professionals with a wide range of experiences that will influence the learning trajectories afforded to them through participation in the INSET.

- In summary, INSET should provide access to resources in relation to meaning, practice, identity, community (Wenger 1998) and confidence. The broader 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.[1]

Notes

1 The conception of the various design features of PLESME as 'dilemmas' held in dynamic tension was co-constructed in a supervisory meeting between myself and Professor Jill Adler. I thank her for her guidance.

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9 Dilemmas of change: seeing the complex rather than the complicated?

Chris Breen

Introduction

In this brief chapter, I reflect on two decades of involvement in mathematics teacher education. The main theme I explore is that our understanding of the field would be enhanced by a move away from a modernist Newtonian paradigm towards one that explores the implications of new understandings emerging from complexity theory.

Then…

My experience of mathematics teacher education over the past twenty years has been at both pre-service level (through my position as a university lecturer in mathematics education) and in-service level (through my work as initiator and then Director of the Mathematics Education Project between 1984 and 1996). Inevitably, having worked in these capacities during the period of struggle that placed education and schools (Breen 1988) at the forefront and then in the subsequent period of challenge to create a new education system after the end of the apartheid regime, a major focus of my work (and my preoccupied thoughts) has been the subject of change.

I started teaching pre-service mathematics teacher education classes on my arrival at the University of Cape Town (UCT) in 1983. After an initial period of four years teaching in a fairly traditional lecture-based format, I realised that I was not achieving the progress with these groups of students that I felt was essential for the times. My early attempts to introduce a sensitivity towards the situation in schools and the need for change in practice were largely based on an appeal to the intellect of these pre-service teachers through my emphasis on the theoretical and philosophical underpinnings of

the need for change. Although the majority of the UCT student body at the time seemed to embrace the rhetoric of struggle philosophy, I could not see any change in classroom practice during teaching practice observation. Even some of the most radical students were extremely conservative in their classroom practice. Consequently, in 1986 I made the decision to shift the entire focus of my approach in lectures (see for example Breen 1992). I began to address the person of the student teacher as a grounding framework by engaging each of them in activities that were designed to cause them cognitive (and sometimes affective) discomfort and require them to reflect on this challenge to their belief system. This reflective engagement was accompanied by the formal requirement for the students to keep a journal throughout the mathematics method course in which they reflected on anything that had struck them during the teaching sessions that impacted on themselves as teacher, learner or mathematician. This change in approach certainly generated a good deal of energy and many challenging sessions in which students became engaged in heated exploratory discussions about their different belief systems in what had become a safe environment for such interactions. Students left the course to go into teaching with a much clearer idea of who they were and of their existing belief system concerning teaching.

And then they entered the schools and I began to get feedback of the difficulties they were facing in implementing their ideas about teaching in sites that presented a variety of realities! The next step in my learning process was to set up a research project in which students who had previously taken this mathematics method class as a pre-service teaching course were surveyed, to get an idea of their current teaching realities and the effect that the course had had on them. The results of this research, which was undertaken with the help of Wendy Millroy, have been variously reported (see for example Breen 1994). While it was clear that the students reported having gained a great deal from the course that they said was of lasting value, they also reported on the enormous difficulties that they had faced when these newly articulated beliefs were put to the test in classroom situations. The power of context became very evident to me, and it was clear that a whole lot more was needed if I was going to provide them with the necessary tools to attempt to live out their beliefs in their school practice.

In a parallel development, in 1984 I initiated a mathematics teacher in-service project which later grew into the Mathematics Education Project (MEP), one

of several emerging non-governmental organisation's (NGOs) working in the field of mathematics education in the country. This involvement in the NGO world made me more aware of some of the larger-scale pitfalls and dilemmas that we were facing at the time, as we shifted our focus onto mainly methodological issues such as problem-centred learning, investigations, etc. Mathematics education NGOs were initially funded by local industry and in general attempted to induct teachers into new methods of teaching mathematics that focused on a variety of more learner-centred approaches to classroom mathematics. The emphasis was on changing the practice of teachers in schools, and concepts such as 'the multiplier effect' (whereby exponential exposure to these 'new' ideas was envisaged) became fundamental tenets of appeals for further funding by these NGOs. In a paper presented at the AMESA conference in Johannesburg in 1994, and subsequently revised for international publication (Breen 1999), I sounded some warnings about the problems that were starting to arise as a result of the outside pressure on teachers to change, and asked whether those doing the changing really understood the process of change and also whether they were themselves open to the need for change in their own practice. I pointed to the inevitable problems that resulted from telling teachers that they were deficient and needed to change in a certain direction and towards a specific endpoint. I also asked whose interests were being served in this mass approach to INSET, and questioned the increasing practice whereby projects reported on the effects and product of their own specific interventions in funding documents whose main aim was to ensure the continuation of the selfsame projects! In particular, I chose to contrast the quotation from David Pimm (1993: 31) in which he stated that 'their change is not our business' with the reality in South Africa where teachers' change was in fact BIG business!

… and now?

I am aware that these brief pre-1995 thoughts belong to a different century, and also that my involvement in both pre- and in-service mathematics teacher education has diminished greatly since I resigned as Director of MEP at the end of 1995, and also reduced my pre-service teaching by almost a third as I started sharing these courses with university colleagues in 1999. The chapters in this section by Mellony Graven and Anandhavelli Naidoo give a broader picture of aspects of the current situation, and further snapshots can be found

in the annual conference proceedings of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE). I have taken a selected sample of recent proceedings in an attempt to identify possible features and strands of the emerging picture.

In the first place it strikes me that most of the major in-service mathematics teacher education initiatives that I was talking about in 1994 are still in existence in one or other form (for example, the Mathematics Education Project now forms part of the Schools Development Unit at the University of Cape Town). One major change is that the courses offered by most of these earlier initiatives are now closely linked to university accredited certificate courses. I am immediately struck by the thought that, since universities in recent times have moved into a bottom-line financial paradigm with a resulting competition for students, it seems that teacher change is still Big Business! There has also been an increased focus on addressing the mathematical content knowledge of mathematics teachers (see for example Adler 2002), and work is being done to determine what sort of knowledge this should be and how university content courses could be adapted to meet these needs.

There is also an increasing amount of research reported at SAARMSE/SAARMSTE[1] conferences on the results of such in-service interventions and a growing agreement on a future research agenda. For example, Ensor (2000) argues that it is the responsibility of mathematics teacher educators to make available as explicitly as possible the form of best classroom practice that they are advocating or certainly privileging. She argues that this privileged pedagogic repertoire needs to be transmitted both linguistically and non-linguistically, the latter through 'ostensive instruction or demonstration in the site of practice' (Ensor 2000: 121). Taole (2000) leads the call for the introduction of a large-scale research project to understand and determine best practice to replace the plethora of small-scale case studies that have dominated the research horizon to date.

> A stage of systemic optimal interaction cannot be attained by tinkering with or tweaking some of the system's components whilst we do nothing about others. This is a lesson that has been learned the hard way by those of us who have been part of the NGO community and chose ill advisedly to work with teachers and sometimes the curriculum neglecting other parts of the system. (Taole 2000: 39)

The careful teaching and research agenda being carried out on the Further Diploma in Education offered at the University of the Witwatersrand, as reported in the SAARMSTE conference proceedings and spotlighted by Brodie (1999, 2000) and Adler (2002), provides much food for thought on these issues. Brodie (1999) reports on the way in which teachers have tried to change their practice to more learner-centred methods as a result of what they have learned in the distance course with residential sessions they have undertaken for the Further Diploma in Education at the University of the Witwatersrand. Despite an emphasis on the use of transcripts of classroom lessons and case studies, and the teaching of content in investigative and problem-solving ways in a disciplined and relaxed environment, almost none of the techniques for co-operative learning were evident in the groupwork undertaken in the lessons observed. Teachers also struggled to know what to do with pupils' ideas and meanings. They could use the same examples that had been given in the course, but couldn't deal with new situations. Their questions remained narrow, indicating that a far more complex analysis was necessary than merely pushing for a shift from closed to open questions. Brodie's conclusion was that, notwithstanding the many positive features, teachers experienced difficulties in changing their practice despite the input given in the FDE course. These findings resonate with much of what has been reported from mathematics teacher education research presented in the SAARMSE conference proceedings of 1999 and 2000 (see for example Boltt et al. 1999; Newstead 1999; Spannenberg 2000 and Stoker 2000).

Brodie concludes:

> It is clear that some fine-tuning of ideas, introducing nuances and textures is important and needs to be handled explicitly in courses. How this is done at a distance provides major challenges for teacher educators in distance programmes. (Brodie 1999: 74)

There is another thread that I want to tug at rather gently which appears in the mathematics teacher education research reported in recent SAARMSTE conference proceedings. It is stated most clearly by Hobden (2000) in her report on research she conducted into the metaphors used by fifty pre-service secondary mathematics teachers for their personal theories of teaching. She found that the group initially overwhelmingly supported simple acquisition metaphors and theories of teaching and that these metaphors were in many

cases adhered to despite formal input from lecturers during the course and the experience of teaching practice. She concludes:

> Pre-service teacher educators would do well to spend time on helping the pre-service teachers to articulate their own personal theories and lay them open to scrutiny. I am not sure that the individual student teachers, nor their lecturers, realise the strong influence these personal theories have on learning, nor how their whole perception of the material presented at College is coloured by personal theories. Teacher educators who do realise this will be in a better position to assist students with accommodating new ideas and more understanding of the reluctance to accept innovations that conflict with deep-seated beliefs about teaching and learning. (Hobden 1999:179)

A resonating conclusion is to be found in the report of Boltt et al. (1999: 66), who remark that 'the research has not explored in an adequate way the importance of taking the "teacher as person" into account in the planning of INSET programmes that will bring about sustainable changes in classroom practice'. Similarly, Graven (2000: 161) concludes that 'from interviews with teachers it seems that the individual trajectories (life goals, existing practices, background knowledge etc.) of teachers have a strong influence on which aspects of the course teachers identify with the most.'

Trying to begin to make some sense of it

My starting point for trying to make some personal sense of the picture of the current phase of mathematics teacher education in South Africa, as described above and in the different contributions to this section of the present book, is an article by Davis and Sumara (1997). In the article, the authors draw a distinction between looking at education as being 'complicated' as opposed to being 'complex'.

> Complexity theorists draw a distinction between the descriptors complicated and complex. This new interdisciplinary field begins by rejecting the modernist tendency to use machine-based metaphors in characterising and analysing most phenomena. Machines, however complicated, are always reducible to the sum

> of their respective parts, whereas complex systems – such as human beings or human communities – in contrast, are more dynamic, more unpredictable, more alive. (Davis & Sumara 1997: 117)

In looking back at mathematics teacher education in South Africa over the past two decades, it becomes evident that while the main focus seems to have remained constant in seeking to change the teacher, the preferred vehicle for this change has moved from educational theory through methodology and content to pedagogic content knowledge and conceptual knowledge-in-practice. The task has developed over the years into one of making more and more explicit exactly what is needed and intended by these aspects of teaching, so that teachers have an optimal possibility of taking up these features. This seems to be clearly based on the complicated view of life and learning in that there is a narrow focus on the teacher (in the position as the learner in the presence of the teacher educator). The later realisation of the crucial influence of context shifted the focus somewhat towards whole school development. However, in the field of mathematics teacher education, this was broken down into the specific and separate task of trying to ensure that there was optimal carry-over from the lecture room to the classroom. From this viewpoint, it is natural that researchers take on as their responsibility the task of finding a better explicit formulation of what the learners (the teachers) need to do to take the lessons from the classroom with them into their sites of work.

> Teaching has been cast as a complicated rather than as a complex phenomenon – one that can be understood by analysing its component parts and one that for all intents and purposes does not vary across time, setting and persons. (Davis & Sumara 1997: 121)

These ideas also suggest that those seeking to make every nuance and texture explicit for others should not be surprised when this does not work to their satisfaction! Similarly, plans to document 'best practice' across a variety of contexts are likely to be counterproductive if taken too far in their expectations. This realisation of the crucial role played by learners and environment at micro and macro levels could free up teacher educators to play with some of the variety of interweaving and interacting features of the learning situation and in so doing gain more insights. For example, teacher educators might find that an attempt to locate and make explicit even their own 'best practice'

in different environments and with different learners is a large yet extremely enlightening challenge.

> An exclusive concern with the components of teaching has always been and continues to be inadequate for preparing teachers for the complex situations within which they will be working. We cannot teach everything that must be known for what is known and the circumstances of that knowledge are always shifting, evolving, unfolding. (Davis & Sumara 1997: 121)

Taking a complex view means that the focus is on the interrelationships of things and the manner in which sub-systems come together to form larger, more complex systems. The theory of enactivism (see for example Davis 1996; Maturana & Varela 1986; Varela, Thompson & Rosch 1991) looks at each learning situation as a complex system consisting of teacher, learner and context, all of which frame and co-create the learning situation. The teacher, at best, can only perturbate the learners who will take on board what they are able to embrace at that moment as a result of their current predisposition from biological, historical and other contextual factors. An enactive view of life leads one to take up a hermeneutic quest to ask questions about the way in which the different parts of the system interact as a whole, rather than look to closure by finding 'facts' about a sub-section of the system. Further implications of enactivism for mathematics education can be found in Begg (1999).

An understanding of the world as a complex set of systems forces us to take a different view of the teaching/learning situation in many ways. One of the major tenets of enactivism is that learning takes place through embodied action. An understanding of this, together with the realisation that the learners (the mathematics teachers) will only take in what they are predisposed to accept, forces the teaching into a much more active listening mode that Davis (1996) refers to as hermeneutic listening. The failure of any complicated teacher education plans to take into account the individuality and self of the mathematics teachers is, for me, therefore doomed to have limited effects. In a similar manner, there is no way that the learning situation co-created by teacher educator, teachers and lecture room can model or add understanding to that co-created by teacher and students in the school classroom.

> Thus we argue that such notions as controlling learners and achieving pre-set outcomes must be set aside in favour of more

> holistic, all-at-once co-emergent curricula that are as much defined by circumstance, serendipity, and happenstance as they are by predetermined learning objectives. (Davis & Sumara 1997: 122)

There is obviously a great deal more thought that needs to go into these emerging ideas. However, they do resonate with Taole's earlier plea to look at the whole system instead of tinkering with or tweaking some of the system's components. They also echo a paragraph in Brodie's report in which she seems to be supporting the complex view of the world by saying:

> How teachers have managed to work with certain ideas in their classrooms also comes from an interaction between the individual teacher, her context, what she has learned from the courses, and what she has learned from other sources. It is not possible to untangle the effects of all the disparate influences on a teacher, to be able to attribute particular changes to a particular input. Nor is it desirable to do so, because the teacher-in-context is always part of and contributing to a range of influences on her practice. (Brodie 1999: 74–75)

In thinking about the chapters of this section, I am aware that Mellony Graven has taken up the challenge of battling with the either/or language of the complicated world view in attempting to resolve the various dilemmas she has outlined, and that this is most clearly evident in her detailed deliberations to resolve the dilemma of site. Her resolution of the issue points to an embracing of the opposite poles of school and university, and the creation of a site in which these aspects are in dynamic interplay – a view that, for me, clearly belongs to the complex view of learning.

> Boundaries that currently define schools and universities should be blurred … so that the relations between that which we call teacher education needs to move away from a model that focuses on mastery of classroom procedures and toward a more deliberate study of culture making. (Davis & Sumara 1997: 123)

Implications for teaching, research and policy?

In closing, I am aware that a major problem with embracing a complex view of the world at the present time in South Africa is that even if it does give a

truer picture of how learning occurs, it does not make any claims to deliver the goods in mathematics teacher education. A researcher might well talk of wanting to maintain and acknowledge the complexity of the issue of mathematics teacher education, but the minute there is an attempt to zoom in on a particular part of the process to find out what's happening one has embraced a complicated rather than a complex view. Inevitably one then tries to 'fix' the part one has researched, even though it does not represent the complexity of the phenomenon in action. Nevertheless, accepting the appropriateness of a complex view of teaching could enable teacher educators and researchers to accept the limitations of a complicated perspective that seeks to make all components understood and explicit. It could increase our capacity to listen to the subtle nuances of the process of mathematics teacher education. It could help us to understand the limits of our power to affect change, as well as the co-responsibility we share with those we work with in designing appropriate interventions. It could cause us to ask questions about what gets lost when we zoom in on a particular aspect of the whole. It could even temper the dominant driving forces in education which, for me, are often located in complicated modernist traditions of 'education as business'.

However, these are more general thoughts which do not address the specifics of what some of the implications of taking a complex rather than a complicated approach might be for policy, research and practice.

As regards practice, I have tried to outline some of the enactive moves that I have introduced into a pre-service primary school mathematics teacher course which I run at the University of Cape Town in Breen (2001). I think that an understanding that a lesson depends not only on the teacher but also on the learners and the environment removes a great deal of the present complicated focus of a lesson from the teacher. In an enactive approach, the teacher has to develop his/her skills as a perturbator and a listener. An absence of listening skills disempowers a teacher from hearing the contribution of the learners. In Breen (2003a) I have attempted to write a workbook for adults who have developed a fear of mathematics which is based on these principles.

Varela (1999) refers to Mencius's comparison of a truly wise person and the village honest person in a discussion on ethics which is based on his work in neurobiology and enactivist ideas. His main point here is that the village honest person is someone who knows what to do in a specific situation provided

that there is sufficient time to think about it and to make a considered decision. The truly wise person, in contrast, does not have to stop and consider what action to take. Through a process which is described as consisting of extension, attention and intelligent awareness, the truly wise person just acts in accord with the situation. My sense is that the policies which are currently being formulated and implemented by the Department of Education in regard to teacher education are geared towards developing village honest teachers rather than truly wise teachers. An emphasis on best practice and set predetermined outcomes to each lesson, in my mind, ignores the complex adaptive system possibility for the emergence of a lesson outcome, and focuses almost entirely on teaching as a complicated phenomenon.

In the area of research, again the complicated view currently dominates and researchers generally set up a template for the correct and accepted form of research with a predetermined question which is to be explored. Enactive research takes one on a different journey (see Haskell, Linds & Ippolito 2002) and here I believe it is the teachers who need to show us the uncomfortable way forward (Breen 2003b). In this regard I have tried to introduce some of these ideas into a new Masters stream in Teaching at UCT and the first dissertations which are emerging from students exploring these ideas are extremely promising (see Eddy 2003 and Claassens 2003) as well as demanding on their supervisor. There is a risk involved in going down this path as one is not certain of the questions which will be asked or of one's destination, but the journey is certainly extremely interesting (Breen, Agherdien & Lebethe 2003).

But these are experimental times, as we try to broaden the possibilities of playing with the textures of the task of teaching and researching mathematics classrooms. In practice, one still finds information by making assumptions that we live in a Newtonian world where there is no friction, no air resistance, etc., and education policy, practice and research will still follow this path. However, I think the crucial lesson from complexity theory is that it teaches us that the world of nuances is much closer to 'reality' than the world of certainty. We need to resist the temptation of being seduced into thinking that it is possible to capture the essence of mathematics education by living and believing that the world is merely complicated! However, this will be no easy challenge.

> Science and experience constrain and modify each other as in a dance. This is where the potential for transformation lies. It is also

> the key for the difficulties this position has found within the scientific community. It requires us to leave behind a certain image of how science is done, and to question a style of training in science which is part of the very fabric of our cultural identity. (Varela 1996: 337)

Notes

1 SAARMSE was established in 1992 as the South African Association for Research in Mathematics and Science Education. As participation expanded to include neighbouring countries, and the significance of technology education increased, the name was formally changed in 2001 to the Southern African Association for Research in Mathematics, Science and Technology Education.

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