

UNIVERSITY OF CAPE TOWN
FACULTY OF EDUCATION

A small-scale investigation into teachers' access to the regulating principles underlying the "new mathematics" curriculum in the Junior Primary phase

A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Education specialising in Mathematics Education

by

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March 1995

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ABSTRACT

This research project focuses on the "new primary mathematics" curriculum that has been implemented in the schools in the Western Cape over the past six years. The specific question I addressed was, "What access do teachers have to the regulating principles underpinning the 'new primary mathematics' curriculum". The term "regulating principles" is drawn from the work of Paul Dowling (1993;98). In terms of this research, the regulating principles are the theoretical underpinnings to the new curriculum, which include substantially a theory of learning.

I explore access to the regulating principles through semi-structured interviews with six teachers, who have implemented this new approach with different degrees of success, as measured in their own terms. I also investigate the official Teachers' Guide for Mathematics (Cape Education Department, 1993) for explicitness of theoretical underpinnings.

An analysis of the teachers' guide indicated that the regulatory principles were not made explicit and the research indicates that the teachers in my sample have restricted access to these principles. I conclude that teachers who have little access to the regulating principles are constructed as a subordinate voice in relation to teacher educators, and must of necessity rely on procedure for their practice and be subject to external validation. This raises questions as to the successful implementation of the curriculum, in that it limits access by teachers to the educational debates surrounding theories of knowledge and theories of learning, and so inhibits teacher involvement in curriculum implementation. It also limits the ability of teachers to interrogate their own practice.

ACKNOWLEDGEMENTS

I am deeply grateful to the supervisor of this research, Paula Ensor. Her commitment, interest and firm encouragement were invaluable.

During this course, there has been valuable input from a number of sources. I would like to acknowledge;

- the contributors to the M. Ed. course, some of whose lectures inspired this research,
- the researcher whose advice, to take risks even if it meant only getting a third, enabled me to enjoy this dissertation,
- Heather Jacklin for her interest, insight and perception,
- Cynthia Anderson for doing the proof-reading,
- Simon James for support and assistance during the year,
- Anna and Maia for being such independent and accommodating little people,
- Alison Long, Rae Anderson, Miriam Xotongo, Nancy Landu, Alicia Yekiso and Rosemarie Naiker for invaluable child-minding support, and finally
- the fellow students on the M. Ed course for encouragement along the way.

This dissertation is dedicated to the teachers who were bold enough to participate, and to curriculum innovators who are bold enough to initiate change.

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Chapter One

INTRODUCTION

1.1 Overview

A "new mathematics" curriculum has been implemented in the Western Cape over the past six years. The curriculum, which was implemented in eight schools in the Western Cape in 1989, is often referred to colloquially as the "new maths". The Cape Education Department and the Research Unit at the University of Stellenbosch have named the innovation the "Problem-solving Approach" or "Problem-centred Learning".

Has the implementation been successful? Have the teachers been able to implement the "new mathematics" in their classrooms? What factors enable teachers to implement new curricula in their classrooms? What are some of the barriers to implementation? These are important questions to be raised by policy makers, educators and teachers concerning any new curriculum, and which I tentatively answer on the basis of a small-scale study.

Curriculum innovation is a complex process. According to Hargreaves and Fullan (1994:4) "Educational reform has failed time and time again". They believe that this is because "reform has either ignored teachers or oversimplified what teaching is about". Von Glasersfeld (1991:xiii) states that failure is the result of a limited conception of knowledge acquisition and a misunderstanding of how children learn. Along with others, who fall into the constructivist camp, he advocates a radical change in teaching style.

I have chosen to look at one aspect of curriculum innovation, namely, the access that teachers have to the regulating principles underpinning the "new mathematics" curriculum, which is, I would argue, an important factor in the successful

implementation of this curriculum. This dissertation is based on the assumption that access to the principles underlying an activity enables one to generalize across contexts, and renders one relatively independent of external control. A further assumption on which this dissertation is based is that there are regulating principles underlying this new curriculum, or that they can be constructed with reasonable coherence if one has access to the right sources.

I, therefore, explore teachers' access to the regulating principles underpinning the "new mathematics" curriculum. In doing this I attempt to construct the regulating principles which in this case I take to be the theoretical underpinnings of the "new mathematics". My theoretical framework is drawn from Paul Dowling, from which I have taken the concept "regulating principles" (Dowling, 1993:98).

This study raises the question of whether access to the pedagogical principles underlying the "new mathematics" curriculum, as well as access to general mathematical principles might render teachers relatively autonomous, and enable them to regulate their own teaching practice. This, I argue, would allow teachers to collaborate with curriculum innovators, and direct their own change, rather than be placed in a subordinate subject position.

This study comprises a dual focus. I look for explicitness of theoretical underpinnings in an analysis of the Teachers' Guide, which I take to be the official means through which theory is communicated to teachers. I also explore access to the regulating principles through semi-structured interviews. I assume that the access or lack of access to theoretical underpinnings will be apparent in the teachers' accounts. I interview six teachers who have implemented this new approach with reasonable success, that is measured in their own terms and that of their colleagues. From the analysis of both interview transcripts and the Teachers' Guide, I conclude that teachers have limited access to the regulating principles. Finally, I put forward possible consequences of this limited access to regulating principles.

In this chapter I provide a rationale for choosing the "new mathematics" curriculum as the focus of this investigation. I then explain the "new mathematics" curriculum¹, by providing a brief history of implementation in the Cape Schools and look at the theoretical origins of this innovation. I then locate this innovation in the South African context and in the broad context of curricular innovation.

My focus is on the teachers' role in the implementation of the new curriculum, and in particular on what access teachers have to the regulating principles underpinning the "new curriculum". In this chapter I clarify crucial points regarding the research question, and then explain briefly my choice of research design.

1.2 Rationale for the Study

Prior to undertaking this study, I conducted a small-scale investigation with parents about the "new maths". This threw up some interesting questions. Conversations among parents, which seemed to indicate the exclusive and illusive nature of the "new mathematics", provoked my interest. Parents were in general confused as to what was required from the "new mathematics". The following were some of the comments;

They're supposed to discover for themselves. You're not supposed to tell them how to do things.

John is battling. He doesn't understand what is going on. But I can't teach him my way. They (the teachers) say that will confuse him.

Mary is flying, her mental arithmetic is fantastic, better than mine ever was!

In a Natal newspaper a letter was published under the pseudonym Roger Rabbit (The Daily News, April 20, 1994), in which the writer was concerned about the maths education in this country. One of his concerns was that a Standard 2 child took half

¹ This topic is dealt with in great detail in Chapter 3, and also in Chapters 5 and 6.

a page to add a simple sum. He also expressed the concern that this "new maths" was the same "new maths" that Britain had rejected in 1972.

At a local school's parent evening the "new mathematics" curriculum was explained and demonstrated. This was attended by parents wanting to know more about the "new mathematics". The Standard 1 teacher gave a brief introduction to the "new mathematics", and then proceeded to teach her three groups. Each group had a turn on the mat, a turn doing activity sheets, and a turn doing games². The parents moved around the room, watching the teacher, observing the children, and having discussions amongst themselves. I questioned whether the parents at the end of the evening were any more enlightened as to what the "new maths" was all about. The parents had been invited into the classroom but had been given limited access to the regulating principles underpinning the "new mathematics". Parents' limited access to the regulating principles led me to wonder whether the teachers themselves had access to the regulating principles underpinning the "new mathematics".

1.3 What is the "new mathematics"?

A "new mathematics" curriculum was implemented in the Western Cape in 1989. The initial experiment was conducted in eight "white"³ schools. A further sixteen schools were included in 1990. Thereafter the new curriculum was introduced in "coloured" schools throughout the country. The DET schools had not officially implemented the curriculum in 1994; however, some schools were implementing it informally. The other provinces responsible for "white schools", were at varying stages in the implementation of the "new mathematics".

² This is a standard teaching method taught to this teacher during her college years thirteen years ago. For a description of what the new maths requires see Data Analysis.

³ In the racially divided South Africa the four provinces, Transvaal, Natal, Cape and Orange Free State, under the House of Assembly, were responsible for "white" education in their provinces. The House of Representatives was responsible for "coloured" education, and the Department of Education and Training was responsible for "black" schools.

In 1987 there was a directive from the executive director of the Cape Education Department to investigate why mathematics was so unpopular amongst children, and to set about improving the image of mathematics education⁴. The Research Unit for Mathematics Education at the University of Stellenbosch (RUMEUS), who were already involved in research in mathematics education, together with the Cape Education Department, looked at research locally and internationally. This led them to plan a new curriculum on the basis of their findings and to implement this curriculum as a pilot project in 1989.

While the origins of the "new mathematics" curriculum are not clearly stated in the Cape Education Department Teachers' Guide for Mathematics, Junior Primary Phase (Teachers' Guide), it can be deduced from some of the quotes that it has been influenced by Piaget, and includes elements of a constructivist approach. Other sources, personal communications with a subject advisor, and a curriculum planner, as well as papers written by the members of the RUMEUS group (Olivier, 1990, Human et al 1989, Murray, Olivier and Human, 1993) indicate that the new approach is compatible with constructivism. Olivier (1990:33) refers to the research of Tom Carpenter (cited in Olivier,1990) as having great relevance in the South African context as it had similarities with the research being done by the RUMEUS group. Another influence, though not directly referenced by the CED Teachers' Guide, but which the Teachers' Guide echoes in places, is the Cockcroft Report (1982).

Olivier (1990) indicates that in mathematics research there is a movement away from looking at the development of individual children's mathematical thought, to their construction of knowledge in the classroom situation. This entails a change of social interaction in the classroom and a change of role for the teacher. This "constructivist" theme is supported by Volmink (1993) who suggests that "the bulk of the curriculum should be based on authentic problems which will force students to engage with mathematical ideas and construct their own modes of expressing their explanations"

⁴ This information was provided in a personal communication with the curriculum advisor.

(Volmink, 1993:36). The role of the teacher is therefore to negotiate with students and to show them how they can make their representations more refined.

While this trend has generally been accepted, as is seen in the adoption of the "new mathematics" in all provinces and departments in the country, there are some warnings and reservations on the part of mathematics educators (Stoker, 1991; Laridon, 1990; and Gordon, 1993). Stoker (1991) argues that rather than "blindly follow the furrows being ploughed in developed countries" (Stoker, 1991:30), we should build on the strengths our teachers already have. Teachers can make a transition from a traditional teaching style to one which involves more classroom interaction by mediating through language, which is a strength of traditional teachers. He warns against requiring teachers to adopt classroom practices they are not comfortable with and not qualified to deal with. Laridon (1990) warns against the "top-down approach" (Laridon, 1990:21) to curriculum development.

What we need in South Africa is proper **curriculum development** based on classroom research relevant to **this country and all its peoples**, resulting in principles from which to proceed (Laridon, 1990:21).

1.4 Curriculum Innovation

Underpinning curriculum innovation is the notion that there will be an improvement in learning outcomes. The learning outcomes are dependent on what happens in the classroom. Inevitably there is a focus on the teacher as "Agent, not Medium, of Change" (Lerman, 1993:221). Whether the teacher is positioned as the initiator of change or the medium of change is a central question. The role of teacher as initiator or teacher as medium, is a determining factor in how curriculum innovation is carried out. In either case, curriculum innovation is dependent on some change within the teacher and her environment. The change may occur within the area of knowledge and skill development, or self understanding, or change within the classroom or school structure. Hargreaves and Fullan (1992:2) talk about teacher development as a specific aspect of curriculum innovation. This is congruent with the aspect of curriculum innovation on which this study focuses, which is on teachers' access to the regulating principles underpinning the curriculum innovation.

Hargreaves and Fullan (1992:2) put forward three views underpinning teacher development;

- teacher development as knowledge and skill development,
- teacher development as self understanding, and
- teacher development as ecological change

(Hargreaves and Fullan, 1992:2)

Knowledge and skill development rests on the assumption that the better teaching strategies teachers have and the more subject knowledge they have, the better will be the learning outcomes. This has involved extensive debate as to the merits of traditional teaching versus pupil-centred teaching. The implementation of curriculum based on this view involves researchers and administrators deciding on certain approaches to teaching and learning. These approaches are then presented in workshops, outlined in Teachers' Guides and presented to teachers as the "new" curriculum.

This type of innovation is usually "imposed on teachers from a top-down basis by 'experts' from outside their own schools" (Hargreaves and Fullan, 1992:3). This approach often fails to involve the teacher, and can run the "risk of not securing their commitment and generating teacher resistance" (Hargreaves and Fullan, 1992:3). In addition, by not allowing teachers the choice regarding the implementation of skills, this "implies a disrespect for teachers' professionalism and the quality of their classroom judgements" (Hargreaves and Fullan, 1992:3).

A characteristic of this approach is that there is "undue confidence and certainty" (Hargreaves and Fullan, 1992:3) placed in educational research, which supports and lends credence to the implementation. From initial observations I question whether research is easily accessible to junior primary teachers and suggest that teachers are not in a position to interrogate the research.

Focusing on knowledge and skills without looking at the teachers' attitudes and beliefs is likely to be ineffective, according to Hargreaves and Fullan (1992:7).

Development involving **self-understanding** must come before any meaningful change can take place. The importance of teachers' development and the importance of teachers' lives and biographies is seen by some (Huberman, 1992, Raymond, Butt and Townsend, 1992) to have implications when trying to implement change in classroom practice. In placing emphasis on teacher development, however there is the danger of imposing a deficit model which places teachers in a subordinate subject position in relation to the teacher developers.

The focus on the whole teacher seems preferable to focusing only on skills and knowledge. However, this focus on teacher development, in addition to the danger mentioned above, has a serious limitation in that it does not take the total situation into account. According to Hargreaves and Fullan (1992:13) the context in which teacher development takes place is crucial to whether change takes place or not. From this **ecological perspective** there are two important contexts, the context of the teachers' working environment and the context of teaching itself.

Hargreaves and Fullan (1992:3) suggest that teacher development based on skills and knowledge development is what is most favoured by administrators. They (Hargreaves and Fullan, 1992:4) suggest that North American approaches to curriculum innovation rely on positivistic research models "to legitimize bureaucratic interventions" (p.4), while in Great Britain "the imposition of the National Curriculum, with all its implications for teaching methodology, are felt to be enough" (Hargreaves and Fullan, 1992:4).

Brown (1990) raises a number of questions about the process of curriculum and pedagogic change in Britain. There are attempts to bring classroom practice into line with the proposed curriculum. It is "assumed that there exists a skill and knowledge deficit on the part of teachers.." (Brown, 1990:199). Brown (1992) warns against accepting unquestioningly the notion of "good practice" as laid down by the Cockcroft report (Cockcroft, 1982:100) and the National Curriculum. He questions the apparently unified origins of the notion of good practice, and the effect this has on the teacher.

In South Africa, certainly in the view of some (Laridon, 1990), a top down approach is characteristic. The curriculum innovation which is the object of this study falls into a knowledge and skill development view of innovation, with certain teaching strategies preferred and a strong notion of what is "good practice". This is supported by current research which is for the most part uncritically accepted by teachers. From within this broad framework my research question focuses specifically on whether teachers have access to the theoretical underpinnings of the mathematical knowledge and the pedagogical skills that they are required to implement. In looking at this question, many other factors related to other aspects of curriculum innovation are brought up.

1.5 Research Question

This dissertation is based on the assumption that access to the principles underlying the curriculum innovation would enable teachers to generalize across contexts, and render them relatively independent of external control. In terms of this study access to the pedagogical principles underlying the "new mathematics" curriculum, as well as access to general mathematical principles underlying the approach would give teachers greater autonomy and enable them to work confidently and creatively within their own teaching environments. What I mean by this is that providing teachers with this access gives them the theoretical tools to investigate their own practice, and to adopt a dominant position in relation to teacher educators.

It is within this context that I ask the question, "What access do teachers in the Junior Primary Phase have to the regulating principles underpinning the "new mathematics" curriculum? My research question is framed within the theory of Paul Dowling (1993), from which I get the term "regulating principles". Dowling's theory is concerned with the principles which regulate school mathematics as an activity, and the strategies used within pedagogic texts to either apprentice or alienate subjects as learners of mathematics. This theory while being developed in relation to school texts has applicability in this area of study. I propose to consider what is

understood by "regulating principles" in the context of Dowling's work, and how access to such regulating principles might impact on educational innovation.

My initial task is to establish the regulating principles of the "new mathematics" curriculum. In terms of this research I understand the regulating principles to be the theoretical underpinnings of a pedagogical approach, and possibly a philosophy of mathematics, which lie at the heart of the "new mathematics". The "new mathematics", as I see it, comprises a pedagogical aspect and a mathematical aspect. In other words, it incorporates theoretical assumptions about learners and about mathematics, largely drawn from constructivism, but from other sources as well⁵.

Thom (1974:204) states that;

...whether one wishes it or not, all mathematical pedagogy, even if scarcely coherent, rests on a philosophy of mathematics" (Thom, 1974:204).

While agreeing with this statement, it is not within the bounds of this study to make a thorough investigation of what mathematical philosophy underpins this "new mathematics" curriculum. I therefore only make tentative statements in this connection.

The second stage involves ascertaining whether the teachers in my small sample have access to the regulating principles underlying the "new mathematics". This I do through interviews with Junior Primary teachers and an analysis of the Teachers' Guide.

Finally I look at the possible implications of access or restricted access for curriculum innovation. This involves looking at some theoretical explanations of access to regulating principles (Dowling, 1993) and hypothesizing from the results of this study.

⁵ Personal communication with the subject advisor and statements in the teachers' guide have indicated that the Cockcroft report has influenced the planning of the new curriculum.

1.6 Research Design and Methodology

The Cape Education Department has commissioned a large-scale study into the effects of the new curriculum⁶, which involves extensive questionnaires, classroom observations and interviews in 20 schools across the Western Cape. By contrast the present study is a small-scale qualitative study in which I interview six Junior Primary teachers about the "new mathematics" curriculum innovation, and seek to ascertain whether they have access to the theory underpinning this curriculum.

The "new mathematics" curriculum, and specifically the teachers' access to the regulating principles underpinning the curriculum, form the focus for this study. I use the descriptive tools of Paul Dowling (1993) and to a lesser extent Basil Bernstein in order to analyze the data.

My research methodology comprises a qualitative study. The case study/interview approach, while having particular strengths, is not without its difficulties. In particular, it involves an "uncontrolled intervention into the lives of others" (Walker, 1986:110). The relationship between teacher and researcher is "necessarily imbalanced with the power on the side of the researcher who is asking the questions" (Goodson, 1991:139). In order to limit the imbalance, and rather regard the teacher as an "extended professional" (Goodson, 1991:139), I chose to avoid observing the practice of the teacher as "a maximum point of vulnerability" (Goodson, 1991:141). I chose to restrict my study to informal semi-structured interviews which provided a "trading point" (Goodson, 1991:148) for me as researcher, and teacher as practitioner.

I felt it important to hear the "teachers' voice" as it is the teacher who is at the "chalkface" (Lerman, 1993:226) of any curriculum innovation. The teachers also form the interface between the curriculum innovators and the pupils. While teachers are in a powerful position in relation to the classroom, their role is often subordinate in

⁶ Personal communication with Hugh Glover at Amesa Conference, University of Witwatersrand, 1994.

relation to the curriculum innovators. Narode (1993) conducted a study at a summer institute where mathematicians and mathematics teachers came together. He concluded that;

In the larger mathematics community, the culture of teaching is subordinate to the culture of creating knowledge. Bringing mathematicians and mathematics teachers together only serves to reinforce the status quo. For two cultures to genuinely interact there will have to be some mutual acknowledgement of the values of each and the differences between them (Narode, 1993:7).

In the words of Mrs Print, one of the teachers in my study;

When he (Professor who was part of the Research team) came in that first year he told me he loved what was happening but it was too concrete. There were too many concrete aids. He wanted them to use this calculator in their head. So I thought O.K. I'll go along with this.

So you see I was really a bit....a bit...what's the word I want to use. He sort of confused me because I had been in the classroom long enough I should have been able to stand firm on what I had already discovered in the classroom. And I thought to myself, "This is a new way" and I fell for this hook, line and sinker. O.K. I thought "Yes, he's right. "He knows more about this." You know he is a maths professor, he must know more about maths than I do, so I succumbed to social pressure there.

I thought to myself, he must know more than I do. I'll go along with this, and you know it was really... It didn't take me too long to discover.... (Transcript, Mrs Print:24)

Mrs Print digressed to talk about her class, then went on to say that she soon realised that her intuitions about what to do in the class had been correct, and that she should not have taken the advice of the "maths professor".

In order to ascertain whether teachers had access to the underlying principles, I interviewed six teachers who were teaching in the junior primary phase. In my sample I included only experienced, confident teachers who had implemented the "new curriculum" in their classrooms, and who were willing to talk about their experiences.

The interviews were informal and semi-structured. The broad focus of the interviews included the teachers' experience of the transition from the "traditional" approach to

the new approach, and the process by which they were inducted into the new approach. An underlying question in my mind throughout the interviews was whether the teachers had access to the theoretical underpinnings.

Subsequently I looked at the "Cape Education Teachers' Guide for Mathematics" to establish whether the theoretical underpinnings were made explicit in that document. There were other documents to which the teachers had access, namely "A Mathematics Curriculum for the Junior Primary Phase: Preliminary Teachers' Guide" put out by the RUMEUS group (Human et al, 1989). In this study I focused on the Cape Education Document, with occasional reference to the RUMEUS document.

1.7 Conclusion

In this study I explore the access that teachers have to the regulating principles underpinning the "new mathematics". Is it the pattern in curriculum innovation that recontextualised knowledge is transmitted from teacher educators to teachers? Are teachers positioned, and do they position themselves, as the subordinate voice in relation to teacher educators without access to the regulating principles? Is the form in which the recontextualisation takes place displaced information without context, theoretical underpinnings, or references to other works which would empower teachers to refute the information, or at least challenge the knowledge transmitters? These are some of the questions addressed in this study.

Chapter Two

LITERATURE SURVEY

2.1 Introduction

In the literature survey I initially did a search on curriculum innovation in mathematics. This brought up particular innovations which fall in the area of constructivist innovation (Ball, 1988, 1990; Von Glasersfeld, 1991, Steffe and Wiegel, 1992), which is what the "new mathematics" approach appropriates. My particular focus was on the teachers' role and more specifically on her/his access to the regulating principles underpinning curriculum innovation. This led me to look at work on teacher education or teacher development. Again there was a lot written from within the constructivist framework of mathematics education, however, in perusing the general education journals and following leads from references, I found work on the teachers' role in curriculum development which related to fields other than mathematics to be relevant to my study. This involved general education (Hargreaves and Fullan, 1992; Fullan, 1990), science education (MacDonald et al. 1985) and primary education (Throne, 1994).

The teacher is seen by some as a key element in the success or failure of the innovation (Lerman, 1992, 1993; Ball, 1990). The teachers' role within curriculum innovation is seen as pivotal (Lerman, 1992) in the success of any innovation, yet should the innovation fail, the blame often falls upon the teachers implementing the curriculum. There is concern for teachers' subject matter knowledge (Bennett and Carre, 1991), classroom practice (Desforges and Cockburn, 1987) and beliefs (Mosenthal and Ball, 1992).

I surveyed the major mathematics journals, Educational Studies in Mathematics, Journal for Research in Mathematics Education, and For the Learning of Mathematics, from 1984 to 1994. I looked at the conference proceedings from

Political Dimensions in Mathematics Education 1 and 2, and Conference Proceedings from Psychology of Mathematics Education, 1986, 1988, 1990 and 1993. Within South Africa I looked at Pythagoras, 1989 to 1994, and the SAARMSE Conference Proceedings, 1993. Following various leads in the literature I came across other interesting studies in other journals; namely, the Harvard Educational Review, the Journal of Curriculum Studies and the Journal of Educational Research.

In this selected review I have drawn out three themes: what the literature has to say about teachers' access to regulating principles in the context of curriculum innovation; the role of the teacher in curriculum innovation, particularly in constructivist innovation; and finally I looked at a research study carried out by a Kindergarten teacher. I conclude by situating my own small-scale study within this sample of current literature.

2.2 Regulating Principles and Teachers' Roles

Brown and Dowling (1993) in a paper scrutinising parents' involvement in the IMPACT project¹, problematize teachers' access to specialised knowledge.

... it may be that teachers are not the most dominant voice in school mathematics because even they do not always have access to discursively elaborated esoteric domain knowledge (Brown and Dowling, 1993:48).

Teachers' lack of subject expertise, insecure mathematics knowledge and a routinization of tasks, according to Brown and Dowling (1993:47), suggests that teachers have limited access to the esoteric domain. This fact constructs them as the subordinate voice in relation to those who have specialised knowledge. This, however, "does not make them any less effective in their role as 'guardians' "(Brown and Dowling, 1993:47). Questions concerning "the distribution of esoteric domain and discursive message with respect to teachers is currently under investigation" (Brown and Dowling, 1993:47).

¹ IMPACT is a project which focuses on involving parents in the mathematics education of their primary school children. Brown and Dowling conclude that parents do not have access to specialised (esoteric domain) knowledge and that the structuring aspects of school mathematics are invisible to parents and children.

A different focus examining the "distinction between procedural ('ritual') knowledge and principled knowledge" is a theme taken up by Edwards and Mercer (1987). In a fascinating research project entitled "The development of joint understanding in the classroom" which involved a qualitative analysis of classroom discourse, they come up with some interesting conclusions. The subject knowledge in this study was physical science, yet it has application for the teaching of mathematics and other subjects in general.

Firstly, in regard to experiential learning and teacher control they conclude;

... The role of the teacher was crucial throughout, both in shaping the general pattern and content of the lesson, and in producing the fine-grained definition of what was done, said and understood. The pupils were in no sense left to create their own understandings and interpretations (Edwards and Mercer, 1987: 156).

Secondly, children's grasp of concepts "was essentially 'ritual', a matter of what to do or say, rather than principled, i.e. based on conceptual understanding" (Edwards and Mercer, 1987:157). While teachers espoused certain educational principles which valued "pupil-centred experiential learning" (Edwards and Mercer, 1987:157), they maintained a "tight control over activity and discourse" (pg. 156). The teachers' dilemma in the classroom discourse is how to maintain control over their class and elicit, seemingly spontaneously, a common understanding while not doing so overtly. The conclusion that the children in their study relied on 'ritual' rather than principled knowledge, points to two interesting questions.

The first, which asks why it is that children rely on 'ritual' rather than principled knowledge, is partly answered by Edwards and Mercer (1987: 158) who argue that much of what children are required to do remains mysterious to them. In Bernstein's terms, (1993) children have no access to the recognition principles, so that realisation in practice comes in the form of what they perceive to be correct in the eyes of the teacher, rather than what they know to be correct in terms of their own understanding. This might also be explained as the children having no access to the regulating principles.

The second question is whether the teachers in the scenario above have access to the regulating principles underlying the particular subject they are teaching, or the regulating principles underpinning the pedagogy they are espousing.

2.3 Curriculum Innovation and Teacher's Roles

Lerman (1993) points to the pivotal position of teachers in curriculum innovation. He states that;

The need for change and development to improve the learning experiences and achievements of pupils everywhere, and in the context of this conference, especially here in South Africa is recognised. The nature of those changes is usually determined by experts ... ,
...but in every setting the person at the chalkface is the teacher. Far from excluding and devaluing the teacher, seeing him or her as the weak link in the impetus to bring about change, teachers must be seen as they are, the initiators of change. (Lerman, 1993:226)

He argues that change will not happen unless teachers recognise their power and play their part in bringing about the change. He claims that teacher research is "potentially transformative in the empowerment of teachers" (Lerman, 1993:226). What is it which is going to empower teachers? Does research allow one access to the esoteric domain, mathematical knowledge or pedagogical knowledge? Or does doing research situate teachers in a dominant subject position?

In Britain the concern about mathematical performance resulted in numerous studies and subsequent reports which tried to upgrade teachers' classroom practice. The Cockcroft Report's "recipe for good classroom practice" (cited in Desforges and Cockburn, 1987:10) in mathematics teaching recommended that;

Mathematics teaching should include opportunities for exposition by the teacher; discussion between teacher and pupils and between pupils themselves; appropriate practical work; consolidation and practice of fundamental skills and routines; problem solving, including the application of mathematics to everyday situations; investigations (cited in Desforges and Cockburn, 1987:10).

Desforges and Cockburn (1987) initiated a two year, in-depth study into the practice of seven experienced first school teachers. This study was initiated in reaction to the

general attitude amongst teacher critics that teachers formed the barrier which prevented pupils from learning mathematics.

Desforges and Cockburn question why teachers do not take the "good advice" embodied in documents such as these. The suggestion that teachers have not been given access to "essential pedagogical principles" (Desforges and Cockburn, 1987:11) has been put forward as to why mathematics curriculum innovations have failed in the past. Kamii (1985, cited in Desforges and Cockburn) suggests that teachers became the "mere executors (if not the executioners) of someone else's decision."

Desforges and Cockburn (1987:11) feel that this explanation is too superficial. They feel that "the resistance to implementing the model runs broader and deeper than that" (Desforges and Cockburn, 1987:11). They cite Ausubel who argues that the single most important factor when teaching a child is to ascertain what the child already knows and then to teach him accordingly. The implications for the classroom of this statement are quite sobering. "The diagnostic programme facing a teacher of thirty children.... would be of such a scale as to ensure that she never got round to any teaching" (Kuhn, 1979, cited in Desforges and Cockburn:14). This points to the impossibility of teachers carrying out the "good practice" suggested in the Cockcroft and other documents, such as the Cape Education Teachers' Guide (1993).

However, given a situation such as this, where the requirements of the curriculum are out of synchronisation with classroom practice, what does the teacher do? Desforges and Cockburn (1987:44) make reference to a teacher who had to make a decision about changing the order of approach in a mathematics scheme. She made the decision "with considerable anxiety in the face of expert knowledge held to be embodied in the scheme" (Desforges and Cockburn, 1987:44). The teachers' actions, as Desforges and Cockburn argue, are necessarily curtailed by the demands of the classroom, but an underlying factor could be the casting of the teacher in a subordinate role in relation to subject experts.

They conclude that the teachers in their study held elaborate views on learning and teaching, and in addition voiced aspirations that were in keeping with those of mathematics experts (Desforges and Cockburn, 1987:155). The constraints of the classroom they believe, did not allow those aspirations to be fulfilled. While the goals and aspirations of researchers and curriculum designers are of importance in themselves it is crucial to consider the constraints within which teachers work.

A question in regard to these conclusions is whether the classroom constraints occur within the four walls of the classroom, or whether the constraining factors are those echos of "good practice" imposed by voices higher up in the educational hierarchy. Again I raise the question about whether the teachers are apprenticed into the pedagogical discourse, or whether they are essentially alienated and are in Kamii's terms "the mere executors.... of someone else's decision" (cited in Desforges and Cockburn, 1987:11). A further question is that while teachers are able to verbalise views on teaching and learning, do they have access to the underlying philosophy or theory on which the theories of teaching and learning are based? The third question in relation to this is, if they do have access, are their own, perhaps unvoiced, philosophies incongruent with the philosophies espoused by the "experts", whether they be psychologists or subject experts?

Closer to home, the Science Education Project, based at the University of the Witwatersrand, Johannesburg, undertook a research project to look at "Teacher reaction to innovation" (MacDonald et al. 1985:145). In the early stages of the project, SEP worked in the Ciskei, but their work was extended to other areas within South Africa.

The researchers (MacDonald, Gilmour and Moodie, 1985), identify three phases through which the in-service programme progresses. The first is the security phase where the teachers' content knowledge is improved. The teacher becomes familiar with new materials and competent with the new apparatus. The second phase is the methods phase, where teachers "concentrate on the acquisition and internalisation of new teaching skills" (MacDonald et al., 1985:261). They become secure with their performance and their content knowledge. The third phase, the aims phase, is where

teachers "contemplate their experiences with the innovation and begin to conceptualise and articulate their own aims, based on the situation in which they function, and their own personal preferences" (Gilmour et al, 1985:261).

These phases they see as corresponding to the differing roles expected of teachers. The security phase corresponds with the teachers' role as subject expert, where their subject knowledge is under scrutiny. The methods phase corresponds with the role of the teacher as classroom manager, and the third phase corresponds with teacher as professional.

These phases are interesting in that they could be seen as stages of an apprenticeship into the esoteric domain. Clearly SEP has something to offer in the form of subject knowledge which includes access to underlying scientific concepts and principles, and methodological principles. The teacher initially subjects himself, or herself, to the subject knowledge transmitted by SEP, and in the acquisition of this knowledge makes a turn about which positions him/her in the role of professional who can negotiate involvement in the SEP programme.

2.3.1 Subject knowledge, maths anxiety, and teacher beliefs

It is clear in the SEP study that access to subject knowledge is crucial for the implementation of the science curriculum innovation. In some of the mathematics curriculum innovations which fall largely under the constructivist umbrella, and certainly the "new mathematics" curriculum, subject knowledge is, in my opinion, undervalued. A survey in Britain by Bennett and Carre' (1991) of teachers' competence to teach national curriculum subjects showed that most primary school teachers felt inadequate with their level of subject knowledge in all areas except mathematics and English. Bennett and Carre's (1991) concern for adequate knowledge is based on the following;

Teachers need such knowledge to adequately transform programmes of study and attainment targets into worthwhile and appropriate tasks, they need it to frame accurate and high quality explanations, and they need it to diagnose accurately children's understandings and misconceptions (Bennett and Carre', 1991:14).

They assessed beginner teachers at the start of their training course on their level of subject knowledge, and again at the end of their training course, and they found small but not insignificant increases in subject knowledge. A closer study looked at the impact of subject knowledge on teaching performance. At the time of writing only music students had been assessed, but they claimed that those with specialist subject expertise were able to "maintain a better balance between teaching and management" (Bennett and Carre', 1991:14) and they had "consistently higher levels of performance" (Bennett and Carre', 1991:14). They conclude that teachers "cannot teach well what they do not know" (Bennett and Carre', 1991:14).

Implicit in Bennett and Carre's assessment of the subject knowledge is the idea that there is a common understanding of what knowledge is and that the canon for subjects such as music, mathematics, biology and science is relatively fixed and can be measured. Cohen (1989, cited in Mosenthal and Ball, 1992) describes a different view of knowledge;

Reformers... see learning as an active process of constructing and reconstructing knowledge. They see teachers as guides to inquiry, who help students to learn how to construct knowledge plausibly and sensibly. **And they see knowledge as emergent, uncertain, and subject to revision - a human creation rather than a human reception.** (Cohen, 1989:16-17) (my emphasis)

This "more uncertain and messy" (Mosenthal and Ball, 1992:347) view of knowledge is the view underpinning constructivist innovations². Mosenthal and Ball cite research as suggesting that "teaching in ways focused on inquiry and understanding depends on the teacher's understanding **and the ability to inquire within** (my emphasis) the subject matter" (Mosenthal and Ball, 1992:347).

Mosenthal and Ball (1992) discuss a classroom-based, long term, in-service programme, Summermath for Teachers, which was part of the Teacher Education and Learning to Teach Study³. The programme was based on elementary school

² See section on Constructivism - Chapter three.

³ See National Center for Research on Teacher Education, 1988, for a full report.

subject matter. This programme is based on a view of learning described as "constructivist", and the problem at issue was whether the teachers' depth of subject matter knowledge affected their teaching in a constructivist model. The analysis draws on interviews with staff members. Staff members who had "weak" backgrounds in mathematics felt that as long as teachers were willing to enquire along with students and construct their own knowledge, it was not an issue. However, the staff members who had strong mathematics backgrounds felt subject matter knowledge was necessary in order to know where the students were going. They conclude that more research is needed in order to ascertain whether constructivist teaching is affected by the level of subject knowledge.

While the focus of the analysis is the staff members of the summer school, there seems to me an artificial boundary between the staff members and the teachers. The subordinate voices (the teachers) are explicitly not given access to the regulating principles of the pedagogic approach, but left to discover them experientially,

By promoting the experience of doing and learning the subject matter, the principles of subject matter coherence and the process of making sense in the subject matter was taught in each program. These principles were foundational to the type of pedagogy promoted, but they were **not taught explicitly** (my emphasis) to teachers (Mosenthal and Ball, 1992:352).

The positioning of teachers in relation to the staff of the project is further evident in another paragraph,

Throughout the discussion, the teachers and the staff concentrated on analyzing Barb's (...a staff member... C.J.) pedagogical approach during the demonstration lesson. No references were made to the mathematics or to doing mathematics. Finally, Barb, glancing at the clock, wrapped up the discussion with a question focusing teachers on the subject matter. She remarked, "There was one thing conspicuously absent from this discussion. What kind of maths were they doing? What did you think about the math?" Directing the teachers to "reflect on that tonight in your journals," she sent them off to lunch (Mosenthal and Ball, 1992:352).

While espousing a "different" form of pedagogy, which is essentially weakly framed⁴ this staff member uses strong framing in relation to the teachers. She uses the

⁴ See discussion on theory.

authority of the clock to close discussion, and techniques which exclude discussion between teachers.

Teachers in this programme are constructed according to a deficit model where the aim of the staff members are to "help" the teachers. According to one staff member, teachers "often have no explicit theory of learning; they think about teaching and what they do, not about what the students do with it" (Mosenthal and Ball, 1992:348). This statement is not backed up by empirical evidence. It certainly conflicts with the Desforges and Cockburn (1987) study and while the study focuses on the staff members, the lack of the teachers' voice is conspicuous by its absence. Nevertheless they state that the teachers' role is very important as the medium through which students master mathematical concepts.

While the Science Education Project researchers (MacDonald et al. 1985) referred to above were aware of the complexities of relationship between implementors and teachers, there appears to be no acknowledgement of the teachers' current expertise on the part of the staff members of the SummerMath for Teachers Programme. In the parallel writing course (discussed along with the mathematics programme) a staff member, herself a professional writer, explained that she

[came to] realize that ... the teachers can't aspire to be writers like I am. But what they can do is they can aspire to be learners... The kind of mentor they can be for [their] kids is really as a learner and a risk taker... In this kind of relationship the kids are seeing their own teachers in the role that they're in as a learner. (Mosenthal and Ball, 1992:355)

This statement implies a view of the teacher as limited in the role of imparting knowledge to an inferior mentor.

Maths anxiety, together with subject knowledge, has been put forward as a reason for the ineffectiveness of mathematics teaching. Wood (1988) in a paper which synthesizes what research tells us about maths anxiety, concludes that maths anxiety is "difficult to define". However, working with the loose definition, Wood makes some interesting points. He argues that the elementary school teacher is constantly being evaluated, and that this constant evaluation is what could lead to

maths anxiety. However, whatever the causes or effects of maths anxiety, a positive attitude is no substitute for a sound knowledge base. I question whether anxiety does not manifest in environments where one feels one has not got access to underlying principles. Mathematics anxiety, as Wood suggests, might be due to lack of subject knowledge. It also might be to do with lack of pedagogical clarity. It also might be a result of threat of evaluation where teachers are positioned as the subordinate voice in a hierarchical situation.

While it can be tentatively hypothesised that the teacher's subject knowledge affects the transmission of mathematics, and that maths anxiety may be related to subject knowledge, the role of teacher beliefs in the teaching of mathematics is an interesting question. For Pirie and Kieran (1992) teacher beliefs are critical. Pirie and Kieran (1992) warn that constructivism cannot be reduced to a set of rules or a set of actions. In their view just as there "are no mathematical understandings out there" waiting to be acquired, there is no "constructivist teaching model" out there waiting to be implemented." They list four tenets of belief (Pirie and Kieran, 1992:507) which they believe are critical for "creating a constructivist environment";

- 1) Although a teacher may have the intention to move students towards particular mathematics learning goals, she will be well aware that such progress may not be achieved by some of the students and may not be achieved as expected by others.
- 2) In creating an environment or providing opportunities for children to modify their mathematical understanding, the teacher will act on a belief that there are different pathways to similar mathematical understanding.
- 3) The teacher will be aware that different people will hold different mathematical understandings.
- 4) The teacher will know that for any topic there are different levels of understanding, but that these are never achieved 'once and for all'.

While liberation from a set of prescribed procedures and recipes for teaching mathematics may be seen as giving the teacher more autonomy, what is the effect of prescribing particular beliefs?

2.3.2 Constructivist curriculum innovation

Teachers are seen as pivotal in the implementation of innovations which fall under the constructivist philosophy. As such, teacher induction is an important ingredient. Simon and Schifter (1991) report an intervention study of mathematics teacher development. The key ideas which guided the intervention were;

1. Teachers must be encouraged to examine the nature of mathematics and the process of learning mathematics as a basis for deciding how to teach mathematics.
2. Teachers' learning can be viewed in much the same way as mathematics students' learning.
3. Provide follow-up supervision and support.

(Simon and Schifter, 1991:312)

The ELM project⁵, was a four stage programme which involved in-service courses followed up by classroom intervention, and then provided a core group of participants with training. This equipped the core group to run in-service workshops in their own schools. Two sources of data were collected and analyzed; teachers' writings (journals) and interviews with teachers.

They concluded that "teachers can develop a vision of mathematics learning and teaching consistent with recent reform movements (as expressed in NCTM, 1989; NRC, 1989)" (Simon and Schifter, 1992:328).

Almost all participants in the project adopted new strategies in their mathematics teaching. More importantly, a significant number of these teachers came to base their instructional decisions on a view of learning as construction. We suggest that the latter represents a fundamental change and, for teachers who reached ACMI Level IVB, is likely to be a lasting one. (Simon and Schifter, 1992)

The aims, results and conclusions of this study seem to be congruent. In my view, this needs further analysis. Were there any dissenting views? What did the teachers bring to the workshop? Did they change their teaching styles because of follow-up classroom intervention or was it consistent with their changed understanding of teaching?

⁵ Educational Leaders in Mathematics Project was conducted as part of the SummerMath for Teachers Program.

The SummerMath for Teachers project by Mosenthal and Ball (1992) was concerned with the perceptions of the staff. In the study by Simon and Schifter (1991) we see some of the teachers' writing, but only as it reflects the aspirations of the course organisers. In the in depth study by Desforges and Cockburn (1987) we hear the teachers' aspirations, their sensitivities to pupils, and their struggles within the constraints of the classroom. As in most research, including this research, the teacher's concerns are constructed through the eyes of the researcher. Lerman (1993) argues in favour of teacher-research, where teachers are posing their own research questions, rather than having a research programme imposed on them by an outside researcher.

In a thought provoking article on teachers as designers of their own professional development, Clark (1992) moves from the view that there is much more to teaching than what is readily apparent, to regarding teachers as reflective professionals, and then finally to the conviction that teachers can become designers of their own professional development. Clark (1992) sums up research on teacher thinking in Clark and Petersen (1986);

In sum research on teacher thinking supports the position that teachers are more active than passive, more ready to learn than resistant, more wise and knowledgeable than deficient, and more diverse and unique than they are homogeneous (Clark, 1992:76).

He concedes that this is an optimistic picture, and not true of all teachers, but true often enough to be taken seriously. This attitude is in direct contrast to the study mentioned above where Simon and Schifter (1992:328) aim specifically to induct teachers into a specific understanding and conclude that "teachers can develop a vision of mathematics learning and teaching consistent with recent reform movements" (1992:328).

In the final section of the literature survey I look at writings of two teachers who reflect on their own experience of curriculum change.

2.4 Teacher as Researcher

A primary school teacher Emma Brown (1994) in an article Empowerment and the National Curriculum graphically describes the impact which an overt external control such as the National Curriculum has on her teaching;

Over the past two years of teaching, a major struggle for me as a maths teacher has been to fight against my constant sense of failing at the job; I have spent huge amounts of energy talking myself out of feelings of despondency and despair. The National Curriculum has contributed to my feeling of inadequacy a great deal, and it has been a difficult but fruitful process for me to find an empowering stance towards the document (Brown, 1994:6).

The statement by this teacher mirrors the dangers of setting up a notion of "good practice" which is difficult to emulate, but which serves as a means of evaluation.

A piece of research executed by a kindergarten teacher, Jeanette Throne (1994) gives an interesting perspective on curriculum innovation. In an article, entitled Living with the Pendulum: The Complex World of Teaching, she shows how curriculum reforms swing from one opposing ideology to another, while teachers cope with the "complex nature of the classroom, where different needs exist simultaneously" (Throne, 1994:195).

As a classroom teacher, every time the educational pendulum swings from one opposing ideology to another, I feel that once again I have been hit by a moving object. (Throne, 1994:195).

In this report she looks at curriculum change from a historical perspective which shows radical swings from one ideology to another. She warns of the danger of polarisation, and from the perspective of the classroom feels that there is never one approach that is going to fit the needs of all the children all the time.

She highlights the difficulty of communicating her classroom experience to educators;

When theory does not reflect the realities of the classroom, classroom teachers working directly with children have difficulty finding common ground from which to discuss these conflicts with educators, whose main responsibilities lie outside of the classroom. (Throne, 1994:196)

This difficulty is further elaborated;

Teachers' voices to authorities are heard when they agree with or accept the changes; their voices are less likely to be heard by administrators, theorists, researchers, or policy makers when they question changes or express concern based on their knowledge and experience. (Throne, 1994:106)

She accepts that teachers do not have all the answers and they need the support and input of the whole educational community, but exclusion of the teachers' voice leads to teachers being pushed from one reform to another without knowing the reasons and with little understanding on the part of the educators of where the teachers have come from and where they are going to.

Finally Throne (1994) looks at the positive value of teachers facing their classroom situations head on, and making decisions on what information they have available to them.

When teachers look at what is in front of them with both eyes, the depth and breadth of their vision is clearer. When they look at the questions and the answers - the possibilities and the limitations - they see new opportunities for themselves and the children they teach. These opportunities merge with their beliefs, knowledge, experiences and concerns as they begin to create a vision of learning and teaching as a multidimensional world that connects the values and needs of a democratic society, the interactive nature of a diverse classroom community, and the uniqueness of each child. This is the complex world of teaching. (Throne, 1994:107)

To conclude this brief survey, I return to Brown (1992), who considers the effects of defining "good practice". This

... fosters the belief that it is the universality of particular practices that should be encouraged, rather than the universality of particular principles and outcomes (Brown, 1992:39).

There is a danger, Brown warns, in setting up ideal teacher and ideal classroom practices, with which all other teachers are compared. Brown brings to our attention "a presumed hierarchy of specialist but generalisable expertise of the researcher academic, and the general but localised expertise of the teacher" (Brown 1992:46). There is no straightforward communication between these two fields of production. He warns against statements about "good practice" on the part of educators. The

two different fields of production "can inform each other but, if it is to be fruitful, it should not be in terms of one dictating or prescribing the activities or practices of the other" (Brown, 1992:48).

2.5 Summary and Conclusion

In this brief selection of papers and research in the field of curriculum innovation, I have focused on the teachers' role in curriculum innovation. I looked initially at what Brown and Dowling (1992) say about regulating principles. I then drew some ideas from Edwards and Mercer (1987) with regard to 'ritual' and principled knowledge, and cite Lerman (1992) who positions teachers in a pivotal role as the initiators of change. Desforges and Cockburn (1987) provide valuable insights into teacher aspirations and the perceived realities of the classroom. Closer to home, I have looked at the Science Education Project Study on curriculum innovation.

I have looked further at what research had to say about teachers' subject knowledge and maths anxiety. Focusing specifically on constructivist innovation, I have considered a constructivist innovation reported by Simon and Schifter (1991). They report an intervention programme, focusing on changing teachers beliefs and classroom practice, which they regard as highly successful.

Jeanette Throne provides an example of teacher-research. A kindergarten teacher talks about the effects of curriculum innovations historically, and warns of the dangers of ignoring the teachers as implementors of curriculum.

The literature surveyed above spans a range of perceptions regarding teachers, from that of a deficit model (Simon and Schifter, 1991, Mosenthal and Ball, 1992) to a model in which teachers are seen as struggling with the contingencies of classroom practice (Desforges and Cockburn, 1987) to a view of teachers as "designers in self-directed professional development" (Clark, 1992:75).

I make the assumption that access to the regulating principles underlying teaching practice would position teachers as self-directed professionals.

Chapter Three

THEORY

3.1 Introduction

My research question, namely "what access do teachers have to the regulating principles underpinning the "new mathematics" curriculum?" is framed within the theory of Paul Dowling (1993). Dowling's theory is concerned with the principles which regulate school mathematics as an activity and the strategies used within pedagogic texts to either apprentice or alienate subjects as learners of mathematics. In order to do this Dowling develops a language of description which, while being developed with pedagogic texts in mind, also has applicability in the larger educational field. I propose to consider what is understood by "regulating principles" in the context of Dowling's work, and how access to such regulating principles might impact on educational innovations. While I draw mainly on the theory of Paul Dowling (1993), I have also found aspects of the work of Basil Bernstein extremely useful.

My task in this project is to establish the regulating principles underpinning the "new mathematics" curriculum. The "new mathematics", as I see it, comprises a pedagogical aspect and possibly a mathematical aspect. In other words, it incorporates theoretical assumptions about learners and about mathematics which are drawn largely from constructivism¹. In terms of this research I thus understand the regulating principles to be the theoretical underpinnings of the pedagogical approach and possibly a philosophy of mathematics, which lies at the heart of the "new mathematics"².

¹ See explanation of theory underlying Constructivism in a later section.

² See page 10.

The **pedagogical roots** of the "new maths" are in child-centred pedagogy and constructivism, both of which have their base in the theories of Piaget. I draw on the work of Valerie Walkerdine (1984) for a discussion of child-centred pedagogy and the links to Piaget's work. For an understanding of constructivism I draw on the work of Von Glasersfeld (1987), Lerman (1989), and Steffe (1992).

The **mathematical roots** are less clear. I have chosen to explore constructivism and intuitionism, which may underpin the new approach, by drawing on the work of Paul Ernest (1991), and Lerman (1989). For the philosophy of mathematics underpinning the constructivist approach to learning mathematics I draw on the work of Lerman (1989). Whether there is a philosophy of mathematics underpinning the "new curriculum" is not clear. However, because there are obvious links with constructivism, I feel it is necessary to explore the philosophy of mathematics underpinning constructivism.

3.2 Fields of Production and Educational Practice

I will briefly outline a model, adapted from Bernstein (1993), which helped me to make sense of this study. I take the position that the Teachers' Guide (TG) represents the interface between the **fields of production** and **educational practice**. In the case of mathematics educational practice, I take the fields of production to be mathematics and psychology. Educational theory, content and procedures I take to be, in Bernstein's terms, a region of knowledge which recontextualizes from both mathematics and psychology. The subject advisors and the research team involved in implementing the new curriculum are the transmitters of knowledge from the region of knowledge production and recontextualization to teachers.

The Teachers' Guide (TG) is a selection from the educational theory, content, and procedures which have been recontextualized from both mathematics and psychology. The teachers on their part recontextualize from the knowledge transmitted to them by education departments and the research team.

Dowling proposes

that (European mathematical) knowledge is: produced as academic practices; recontextualized as official pedagogic practices; transmitted as local pedagogic practices; and acquired as operationalized mathematical practices (1993;35).

The classroom itself, however, might be resolved into two contexts for the elaboration of mathematical practices. These contexts are the fields of 'reproduction' where practices are produced for, or on behalf, of the teacher, and 'operationalisation', where they are produced by the students (1993;36).

The four fields of production referred to in the first paragraph relate to school mathematics. My research question bridges two stages. It spans the second stage in the model where knowledge is recontextualized as official pedagogic practice and the third stage where knowledge is transmitted as local pedagogic practice.

What gets transmitted from the field of production into the classroom and how it gets transmitted are questions fundamental to this piece of research.

3.3 Research Question

What access do teachers have to the regulating principles underpinning the "new mathematics" curriculum? This question embodies two aspects; firstly, what are the regulating principles specific to the "new mathematics" curriculum, and secondly, what are the implications for teachers of gaining access to the regulating principles.

3.3.1 Regulating principles underpinning the "new mathematics"?

The regulating principles underpinning the "new mathematics" curriculum, while not being clear, can be "constructed" from various sources. In this section I plan to look at possible sources where the principles underpinning this innovation are to be found.

3.3.1.1 *What is the "new maths"?*

The theoretical origins of the "new mathematics" are not explicitly stated in the Cape Education Teachers' Guide for Mathematics (1993), or in a document put out by the RUMEUS³ group entitled A Mathematics Curriculum for the Junior Primary Phase: Preliminary Teachers' Guide (Human et al, 1989). What is outlined is a new approach, the essential characteristics of which are that children are "active mathematical thinkers"(TG:1), who construct meaning for themselves on the basis of what they already know, that teaching is directed "at the less sophisticated direct methods often invented by young children of their own accord" (Human et al, 1989:1), and that the teacher plays a facilitating role, where he/she focuses on "understanding the pupil's way of thinking" (Human et al, 1989:2).

In an **interview with a subject advisor** who was responsible for advising two of the teachers in my sample, two interesting factors emerged; firstly the rationale for implementing the new curriculum, and secondly, the theoretical base for the curriculum. The rationale for the alternative approach in the "new mathematics" curriculum was to "make mathematics more accessible to more children" (Transcript D:1). She explained that according to research on the part of the RUMEUS group, and also research in Holland and America, it had been found that the sophisticated methods taught in the traditional approach were beyond the grasp of the junior primary child.

This rationale for the new approach was echoed in the RUMEUS document (Human et al., 1989) which had this to say regarding the new approach;

It is extremely important that the teacher should recognize that the change of approach is not a vote of no-confidence in the teachers: the traditional approach to the early teaching of mathematics had not been created by the present generation of teachers, it had evolved over centuries of cultural tradition and teachers had been implementing it courageously, with good intentions and often, in the light of what is known, remarkable success. The fact that it had been overambitious as to the level of arithmetical

³ The Research Unit for Mathematics Education at the University of Stellenbosch has been, together with the Cape Education Department, been responsible for the implementation of the "new mathematics" curriculum. (Personal communication with curriculum advisor).

sophistication required by young people (my emphasis) is not the fault of any teacher or group of teachers:.. (Human et al, 1989:7).

I asked whether the new approach was based on the RUMEUS research. Her response was that it was also based on the research by Paul Cobb and those "busy with constructivism"; however it was not, in her view, only based on constructivism. Constructivism was "accommodated", but their approach fell under the general heading "child-centred learning".

CJ: You say you accommodate the constructivist approach. To what extent do teachers have to be au fait with what is behind the constructivist approach to mathematics?

Subj Adv: They must know what it is based on. That is why I put together a Teachers' Guide.....

You must have a look at that, the first three chapters especially chapters one and two. That is the theory behind and chapter three is on computational methods.

CJ: That is drawn from this constructivist research?

Subj Adv: From research, I won't say only from Constructivist (Transcript Mrs D:6-7).

She also said that while constructivism is reflected in the new approach, child-centred learning is what underpins the new curriculum.

CJ: Child-centred or problem-centred?

Subj Adv: Problem-centred is used for the child, not for the teacher. It is used for the child to put the child in the position, because children can solve problems (Transcript Mrs D:6).

From the above characteristics, and an oblique reference to a Piagetian/Constructivist framework⁴, the new maths can be positioned within a Piagetian/Constructivist/Child-centred pedagogy⁵. My research question, while not focusing directly on the specific curriculum innovation, but rather on the teachers' access to the regulating principles underlying the curriculum innovation, nevertheless highlights some issues within this particular innovation. It is also important in the light of later data analysis to raise some points about Piagetian, Constructivist and Child-centred pedagogy.

3.3.1.2 *Piaget, child-centred pedagogy and constructivism*

In the above three related pedagogies the learner (pupil) is constructed in a particular way. We have come to regard the developmental stages underpinning Piagetian theory as a "fact" which, however, needs to be seen within a theoretical context.

a. *Child centred pedagogy*

For a discussion and critique of Child-centred pedagogy and its alleged link with Piaget, I have drawn on the work of Valerie Walkerdine (1984). "Child-centred" pedagogy, a general term under which much of modern primary education falls, is premised on the notion of the "developing child", and which locates certain capacities within the child (Walkerdine, 1984:155). What these capacities are, and how they develop, falls within the domain of developmental psychology. The "central focus of this pedagogic practice" is the "observation, monitoring and facilitation of an actual sequence of development" (Walkerdine, 1984:163). Walkerdine (1984) puts forward

⁴ I quote Human et al (1989:4) "Within the framework of Piagetian/constructivist learning theory this information strongly suggests that it could be highly advantageous to base the initial teaching of whole number arithmetic on these alternative methods rather than on the traditional "column" or "digitwise" computational methods."

⁵ In a conversation with a subject advisor of the CED it was established that the new approach could be termed child-centred. Problem-centred came under the umbrella term child-centred, and constructivism was accommodated, but other educational theories also fed into the new approach. The advisor mentioned the research of the RUMEUS group, Paul Cobb, Irma Yackel, and Elizabeth Fennema as having had an important influence. In a conversation with a curriculum advisor, it was established that input had come from the RUMEUS group, whose philosophy is constructivist, but also another group, the Goldfields Resource Centre, who draws on cognitive science.

the hypothesis that "developmental psychology is premised on a set of claims to truth which are historically specific and which are not the only or necessary way to understand children" (Walkerdine, 1984:154). She aims to establish that the pedagogical practices are not the applications of developmental psychology, but are "centrally and strategically implicated in the possibility of a developmental psychology itself" (Walkerdine, 1984:154).

b. Piaget and child-centred pedagogy

Walkerdine (1984) argues that it is the historical conditions of production which made possible the development of Piaget's work and the child-centred pedagogy. There is an interrelationship between the two phenomena but there is no Piagetian pedagogy. The concept of a "developing child" has to be understood in terms of its historical context. According to Walkerdine (1984) Piaget developed his work in direct opposition to Social Darwinism, which pointed to the "inevitability of war", instead of a "peaceful world peopled by rational human beings" (Walkerdine, 1984:170).

Both the teacher and the child are constructed within this particular form of pedagogy. The child progresses through "normalised" developmental stages, the teacher lets the child work at his/her own pace, classroom conditions permitting, under her strict monitoring. While the child can no longer be classified as intelligent/not intelligent, he/she now moves through normalised developmental stages. This is a given, it is not open to challenge or to rigorous reappraisal. However the teacher, to whom this charge has been allocated, is responsible for providing the specified environment in which she/he is able to actualise this potential.

The normative production of "good teaching" means that the teacher must experience herself as inadequate, feel guilty, anxious and insecure. If the child has failed, by implication the teacher's gaze has not been total enough, she has not provided enough experience, has committed the sin of pushing the child (Valerie Walkerdine, 1984:193).

Within the scope of this study, I do not attempt to challenge "child-centred" pedagogy⁶, or to proclaim its virtues, but what is important is that the theoretical underpinnings are made clear. Without the theoretical underpinnings "child-centred" pedagogy becomes a set of "good practices" (Brown, 1992, Ensor 1994) without foundation. When the pedagogy fails, it cannot be attributed to the child, as he/she has all that is required located "within", but there is a danger that the failure can be attributed to the teacher who has not created the right environment for the child to develop these innate capacities.

Given the parameters of this study, I cannot do justice to either a critique of constructivism, or an appraisal of the contribution it has made to mathematics teaching. But what I intend to highlight is that lack of access to the radical philosophical underpinnings of constructivism renders the teacher disempowered either to transform the theory into classroom practice or to criticise the theory.

c. Constructivism

c.(i) Basic principles

Von Glasersfeld (1989) distinguishes two basic principles of Constructivism. The first is that "knowledge is not passively received but actively built up by the cognizing subject". The second principle which follows on from the first is that "the function of cognition is adaptive and serves the organisation of the experiential world, not the discovery of an ontological reality" (Von Glasersfeld, 1989:182).

The first principle we can perceive as being linked to Piagetian theories of learning (Lerman, 1989). The second, an extension of Piagetian theory, is a radical challenge to a representational view of mind (Cobb et al, 1992). Paul Ernest (1993) identifies different forms of constructivism.

⁶ I refer readers to Walkerdine (1984).

c.(ii) Different forms of constructivism

Information processing constructivism is based on the first principle but does not take cognizance of the second. Information processing constructivism "recognizes that knowing involves active processing, that is individual and personal, and that it is based on previously acquired knowledge" (Ernest, 1993:2).

Radical constructivism is based on both the first and second principles. Von Glasersfeld (1987) uses the analogy of an explorer versus a builder;

From an explorer who is condemned to seek "structural properties" of an inaccessible reality, the experiencing organism now turns into a builder of cognitive structures intended to solve such problems as the organism perceives or conceives (Von Glasersfeld, 1987;5).

Radical constructivism also takes its roots from Piaget's genetic epistemology, but enlarges on that in that objective reality is replaced by the experiential world of the cognizer.

Social Constructivism according to Ernest (1993), draws on Vygotskian roots rather than Piagetian roots. "The social constructivist model of the world is that of social reality, the socially constructed world which creates (and is constrained by) the shared experience of the underlying physical and social worlds" (Ernest, 1993:2).

From the above brief consideration of constructivist theory, it is clear that claiming that a curriculum is based on "constructivist" philosophy is but a first step in uncovering just what the underpinning theoretical principles are. The implications of the above three approaches for the classroom teachers are very different. A teacher basing her teaching on an information processing constructivism might have a different methodology from a radical constructivist. These issues are however not mentioned in the document.

c.(iii) Critiques of Constructivism from within constructivism

Within the literature that identifies itself as "constructivist", two key areas which I think need serious consideration have emerged. The first area is one which is

identified by Von Glasersfeld (1987) and the second is identified by Steffe and Wiegel (1992).

Von Glasersfeld (1987) sees the traditional conception of knowledge as having "serious consequences for our conceptualization of teaching and learning" (Von Glasersfeld, 1986:6), and proposes an alternative model. He sees "knowledge and competence as products of the individual's conceptual organisation of the individual's experience" (Von Glasersfeld, 1987:16).

However, the teacher's role is no longer to "dispense 'truth'" (Von Glasersfeld, 1987:16), but to help and guide the student "in the conceptual organisation of certain areas of experience" (Von Glasersfeld, 1987:16). Two things are required from the teacher in order to do this; firstly to have an adequate grasp of where the student is conceptually, and secondly, to have an adequate idea of his/her destination. To generate a "model of child's present conceptions and operations" (Von Glasersfeld, 1987:16) is feasible. He argues that teachers generally have a good idea of where their children are in terms of understanding, but to frame this in terms of a "model of the adult conceptualisations to which his guidance is to lead" (Von Glasersfeld, 1987:16) is more difficult. Von Glasersfeld (1987) acknowledges this. "The structure of mathematical concepts is still largely obscure", and the kind of analysis "that would yield a step-by-step path for the construction of mathematical concepts has barely been begun" (Von Glasersfeld, 1987:16).

For the teacher following the constructivist principles which Von Glasersfeld advocates, this problem may manifest in their practical day-to-day reality, but without access to the conceptual tools of Von Glasersfeld, how do they explain their insecurity about where they are heading?

Steffe and Wiegel (1992:447) argue that the constructivist approach necessarily involves a different school mathematics programme, which is determined by social interaction between teachers and pupils. At the present moment, while there is some reform in the direction of "constructivist mathematics", the mathematics that is taught

higher up in the schools is conventional. Consequently this involves a transition from a constructivist approach to "traditional mathematics" somewhere along the educational hierarchy.

There is the debate among academic mathematicians about whether mathematics is an objective truth (Platonist philosophy) or whether it is socially constructed. However as far as school mathematics is concerned, there is a language to be learnt, a "highly explicit grammar" (Dowling, 1993:176) with rules and formal structures, as well as specific content and forms of expression (Dowling, 1993:377). Pimm (1987) says that "learning to be a mathematician is learning to speak like a mathematician" (Pimm, 1987). There is a strongly classified esoteric domain into which aspiring mathematicians are to be apprenticed.

Teachers trying to implement a "constructivist approach" may wonder at the circuitous route when in the end they revert to "conventional" mathematics. The academic debate happens among mathematicians at a university level, but it is not a debate to which teachers, and certainly primary teachers, have any access.

3.3.1.3 *Mathematical philosophies*

Is constructivism a theory of learning or a theory of mathematics or both? Or does it embrace both in a theory of knowing?

While constructivism has become a pedagogical approach, how is it located within the world of academic mathematics? The "modern" maths of the sixties followed a formalist tradition, in which mathematics can be expressed in formal systems. The constructivist philosophy is often connected with Intuitionism (Davis and Hersh, 1981, Ernest, 1991, Lerman, 1989).

Lerman proposes that constructivism has some similarities with Intuitionism but is fundamentally different. Constructivism that has historical links with Intuitionism he terms C1, and the constructivism which has its roots in Piaget's genetic epistemology

he calls C2. Both adhere to the importance of construction in concept formation (Lerman, 1989:215).

The fundamental difference is that "Intuitionism is an epistemology of mathematical knowledge, concerned with a programme to establish the certainty of mathematics, based on the apriority of time and subsequently of the integers, to be grasped by intuition." C2, radical constructivism, has, in Lerman's view, "a more complete and consistent view of coming to know, of knowledge and of mathematics" (Lerman, 1989:216). Radical constructivism is a relativist epistemology, which advocates that there is no certain truth. "If it is accepted that the way the world works is not forced upon us by that world (empiricism), nor do we have this knowledge innately (platonism), then what we know becomes conjecture, theory and hypothesis" (Lerman, 1989:216).

Locating the "new mathematics" within constructivism raises questions about the nature of mathematics, but this is not discussed in official documents. It is, however, an important issue that needs to be drawn out. In the experience of some teachers in my sample⁷, there is a conflict in methodology which I think is due to a different understanding of mathematics. When teachers are asked to take students through the process of constructing "their own" mathematical truth, is activity grounded in a belief in the certainty of mathematical knowledge, or a belief in a relativist epistemology?

3.3.2 What are the implications for teachers of gaining access to the "regulating principles" underpinning the new curriculum?

The broad area of interest in which my research is located is the implementation of the "new mathematics" curriculum. More specifically, my focus is upon teachers' access to the regulating principles, underpinning the initiative. In order to answer the above question, I draw on the work of Paul Dowling (1993) and Brown and Dowling (1993). The term "regulating principles" needs to be understood from the context of Dowling's work.

⁷ See Chapter 6.

3.3.2.1 *Modes of practice*

Dowling (1993:52) draws a distinction between **modes of practice**; those which are abstract and relatively context-independent and those which are concrete and context-dependent. He uses the terms high discursive saturation and low discursive saturation to differentiate practices.

Practices which exhibit low discursive saturation are context-dependent since they do not incorporate explicit regulatory principles. The availability of such principles in practices which exhibit high discursive saturation renders them comparatively independent of any immediate context (Dowling, 1993:52).

Mathematics is a practice which exhibits high discursive saturation.

3.3.2.2 *Domains of practice*

In addition to discursive saturation, Dowling (1993:94) describes a further dimension for the differentiation of practices. All activities constitute a domain of practice which is strongly classified with respect to both content and mode of expression which Dowling terms the esoteric domain. The esoteric domain is constituted by the regulating principles of an activity. In order to apprentice subjects to the esoteric domain, the activity must cast a recontextualizing gaze outside itself in order to produce a domain of practices which exhibits relatively weak classification with respect to form and content. This is referred to as the public domain. The public domain thus constructed appears to be non-specialised with respect to other activities, but remains subject to the regulating principles of the esoteric domain.

The esoteric domain of school mathematics, by virtue of DS+ (high discursive saturation) and its highly explicit grammar, thus describes practices which are outside the esoteric domain in terms of its own highly explicit grammar. For example, school mathematics, in order to apprentice subjects to the esoteric domain, casts its gaze onto pupils' everyday experiences in order to constitute the public domain. However, the recognition and realisation principles are necessarily those of the esoteric domain, which establishes what is to count as mathematics. Evaluative principles are thus established within the esoteric domain.

From the above I hypothesise in relation to this research that access to the explicit regulating principles underpinning a curriculum innovation renders teachers context independent, while restricted access to the regulating principles renders teachers context dependent. Practices which exhibit high discursive saturation make explicit the regulating principles, so, within my research, rendering teachers relatively free of context would require access to the theory of pedagogy, and possibly, the theory of mathematics underpinning the "new mathematics" curriculum.

3.3.2.3 *The production of subjectivity*

Access to regulating principles is a key factor in the **production of subjectivity**. Pedagogic practice constructs transmitters and acquirers. "The transmitter is in possession of the regulative rules of the practices of the activity which the acquirer is to acquire" (Dowling, 1993:100). "Dominant and subordinate subject positions are constructed via the distribution of practices" (Dowling, 1993:100).

The dominant acquirers are constructed by pedagogic action as "to-be-apprenticed" while the subordinate acquirers are constructed as "to-be-alienated". The apprentice will proceed from the public domain to the esoteric domain, through having access to the regulative principles of the esoteric domain.

The alienated subject is denied access to the regulative principles. Lack of access to the regulative principles of the activity "must render the subordinate dependent on the dominant" (Dowling, 1993:102).

My research question relates to how official pedagogic practice (Dowling, 1993:35) constructs junior primary teachers. What is their subject position in relation to the apprentice - alienation dichotomy? Access to the regulating principles apprentices into the esoteric domain, whereas restricted access leaves the subject in the public domain. The apprenticing or alienating of subjects is achieved through the distribution of message strategies.

3.3.2.4 *Message strategies*

Dowling (1993:102) argues that the reproduction of activities is achieved through **message strategies**.

Message strategies must reproduce, firstly, the esoteric domain of practices. This must include the (re)production of the regulative principles of the esoteric domain.... (Dowling, 1993:103)

...however, the distribution of practices to subordinate subject positions (non-apprenticed voices) is such that there is no or limited access to these regulative principles in discursive form. The esoteric domain must therefore be (re)produced in a second form which obscures its regulative principles. The message strategy to achieve this is referred to as procedure. (Dowling, 1993:103)

Strategies which construct a dominant subject position are referred to as **generalising strategies**; they "minimise the local specificities of the acquirer and maximise the generalities of the esoteric domain" (Dowling 1993:104). Strategies which construct a relatively subordinate voice are referred to as **localising strategies**.

Referring back to my research question, what message strategies predominate in the transmission of the new maths curriculum to teachers? Are they generalising strategies or localising strategies?

3.4 **Elaborating the Research Question**

The research question, "What access do teachers have to the regulating principles underpinning the 'new mathematics'?" is framed within the theory outlined above. The focus of the investigation is at the interface between the production of knowledge and the transmission of that knowledge to teachers. What is transmitted to teachers? Is it the regulating principles underpinning the "new mathematics" or is it merely procedural knowledge which has become separated from the theories underpinning the "new mathematics"?

Implicit in my research question are eight interlinked sub-questions, three dealing with the Teachers' Guide and five relating to discussions with teachers.

With respect to the Teachers' Guide I am concerned with the following:

1. In what form is recontextualised official pedagogic practice transmitted to teachers in the Teachers' Guide? Does it exhibit low discursive saturation, context dependence and limited access to regulative principles?
2. How are junior primary teachers (acquirers) constructed by the Teachers' Guide? (The "model reader" (teacher) does not reside within the work but "resides within a critical reading of the work" (Dowling, 1993:74). Are they "to-be-apprenticed" or "to be alienated"? Have they access to the regulating principles?
3. What message strategies predominate in the Teachers' Guide? Are they generalising strategies which focus on the esoteric domain or are they localising strategies which focus on specific contexts?

The following four questions relate to the transmission of recontextualised knowledge within local pedagogic practice. The Teachers' Guide, lectures, workshops and personal contact between teachers and with subject advisors and the research team form the interface between the official pedagogical practice and the local pedagogic practice. In looking at the interview transcripts, I ask the following questions;

1. Are teachers able to articulate the underlying theoretical principles? Do they demonstrate context dependency or are they able to articulate these principles independently of the immediate context of the classroom?
2. From a critical reading of teachers accounts, do they experience an apprenticing into the esoteric domain? If so, are they able to use the regulating principles in organising their own practice? To what extent are they alienated from the esoteric domain and therefore reliant on procedure?

3. Are teachers able to generalise across contexts or are they tied to localised specificities?
4. In terms of the classroom, according to teachers' accounts, what practices are produced by the teacher? Are these practices congruent with what is set out in the Teachers' Guide? What is their report on children's operationalisation of mathematical knowledge?
5. Finally, and crucially, what is mathematics according to the Official Pedagogical Practice (as expressed in the Guide)? From a critical reading of the Guide, I compare what is in the Guide to the rhetoric surrounding the "new mathematics" as expressed by the teachers, and then reflect on what the teachers' say about the "new mathematics" as it is implemented in their classrooms.

3.5 Conclusion

In summary, I would argue that access to the regulating principles of the esoteric domain renders the teacher relatively independent of context, relying on theory rather than procedure to regulate his/her practice and able to generalise across contexts. In terms of this research, access to the pedagogical theory underpinning the new maths, that is, an explicit theory of learning and theory of instruction, enables the teacher to articulate the theory. Access to the theoretical underpinnings enables theory rather than procedure to regulate her practice. By taking a position within the esoteric domain she is relatively independent of external control, and in implementation, can use theory to interrogate her practice.

With no access to the theoretical underpinnings the teacher is reliant on "good practice" as outlined in the teacher's guide. These procedures are intended to regulate her practice. However, should these procedures conflict with theories already in place, she has no recourse but to abandon the procedures. This scenario also lends itself to external means of control, such as visits from subject advisors

authorizing what she does in the classroom, and external-internal means such as guilt inducing strategies, in order to ensure that the procedures are implemented.

I hypothesise that access to the theoretical underpinnings of the pedagogy is essential for the teacher to interrogate his/her own practice independently of "outside" experts, and for establishing the validity of the pedagogy.

Chapter Four

RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

My research design comprised a qualitative study which included three related aspects. The first entailed **interviews** with Junior Primary teachers and subsequent analysis. The second aspect involved an analysis of the Cape Education Teachers' Guide for Mathematics (TG) for the Junior Primary Phase (1993). A further aspect, which was a further exploration into the process of curriculum innovation (the "new mathematics" curriculum), involved a short interview with a subject advisor, and a brief telephone interview with the curriculum advisor from the CED (see page 33).

I decided not to conduct classroom observations¹ as I did not feel this to be necessary within the scope of this particular research. I wanted as far as possible to avoid an unequal relationship, and felt that interacting on neutral territory would achieve this. Clearly though this is an important aspect, and would provide different understanding of the impact of this curriculum innovation.

4.2 Sample

I constructed my sample to include teachers said to be experienced, confident and competent by principals, or in one case (Mrs Huntley²) by the subject advisor, and who were implementing the "new mathematics" in their classrooms and were willing to talk about their experiences. The reason for this was that I did not want the concerns of implementing a new approach to be dominated by issues of day to day classroom management. Another factor which I felt to be important was that the

¹ See Chapter 1.

² All names of teachers and schools have been changed.

teachers should voluntarily participate in the project. In making this choice I was influenced by Desforges and Cockburn (1987:23), who had a similar criterion for the selection of teachers.

In all cases the criteria were met. The teachers ranged in experience from thirteen to thirty one years. In general, they were regarded as confident and competent teachers by the people who referred them, and during the interviews none of the concerns expressed could be attributed to lack of teaching skill. However, there were distinct differences when it came to their confidence and competence in regard to mathematics. This was not directly attributable to their mathematics qualifications. Mrs Joshua, although having only a Standard 8 qualification, seemed to be a confident teacher of mathematics³.

I interviewed six teachers who were teaching in the Junior Primary phase⁴. To establish uniformity, I attempted to restrict my sample to Standard 1⁵ teachers for two reasons. Firstly I assumed that mathematics would be an important focus by Standard 1, whereas reading and writing might be the emphasis in the first two years. Secondly, I assumed that in the present schooling system, the Standard 1 teachers would in all likelihood be heads of department and so would be in touch with what was going on in the whole of the junior primary.

As it happened, my sample consisted of four Standard 1 teachers, three of whom were heads of department and one of whom had been head of department the year prior to voluntary retirement⁶. The other two were Sub A teachers. Two of the

³ This will be discussed under data analysis. As it was not the focus of this study, any clear statement concerning the relationship of mathematics qualifications to teaching ability cannot be made on the grounds of this research.

⁴ The Junior Primary Phase includes the first three years of schooling.

⁵ Standard one is the third year of schooling.

⁶ See table, Appendix B.

Standard 1 teachers were from the Cape Education Department⁷, although in different schools, while the other two Standard 1 teachers and the two Sub A teachers were from two House of Representative schools. One of the Standard 1 teachers had taken early retirement, but had formerly taught in an HOR school. The other three were teaching at the same school. The two Cape Education Department (House of Assembly) teachers had been involved in the "new mathematics" programme⁸ for six and five years respectively.

4.2.1 Selection of schools⁹

I initially set out to include in my sample teachers from all three schooling systems, organised racially for whites, coloureds and "Africans". I felt that a comparison of the three sectors might throw up significant differences. However, as these three groups were at different stages in the implementation process, this was not feasible. While some black schools were implementing the new approach voluntarily, it was not a departmental requirement.

4.2.2 Interviewees

Mrs Print has been involved in the curriculum innovation project from the start, that is 1989. The school, River Primary, in which she taught was one of the initial eight project schools. I heard about Mrs Print from a friend who knew I was interested in the "new mathematics". She reported that Mrs Print was an experienced teacher, who was in the process of teaching the "new mathematics" curriculum.

I phoned her, explained my project, emphasizing the importance of the teacher's voice, and asked if she would be willing to participate. She agreed but said she was very busy over the next three weeks, but once her reports were over I should phone

⁷ The education system was formerly segregated in terms of colour. The House of Assembly (for "whites") had an education department in each of the former four provinces. The Cape Education department was responsible for the education of white children in the Cape Province. The House of Representatives was responsible for the education of "coloured" children throughout the country.

⁸ See "What is the "new mathematics" on page 5 in the introduction.

⁹ See table page 56.

her again. We agreed that I should write a letter to the principal informing him about the project and requesting an interview. I wrote a letter to the principal requesting to interview a Standard 1 teacher¹⁰.

Two weeks later I phoned and left a message. Then I bumped into her at school where my daughter was attending a gymnastics class. We then arranged a meeting for two weeks hence. All in all the time between requesting the interview and the interview taking place was one month.

Mrs Print was busy in her classroom when I arrived. She expressed a fear that I might have forgotten about the meeting. She asked how I wanted to structure the interview, and I indicated I was happy for her to talk, but that I would look at my notes towards the end of the interview to check that we had covered everything.

Mrs Roberts had been part of the follow-up sixteen schools. She taught at Nerina Junior School. I approached the headmistress, Mrs Cawood, of Nerina Junior School, explained the project, and said I was interested in interviewing one of the teachers in her school, possibly Mrs Roberts. I subsequently wrote a letter including a brief summary of the project, the information I needed from teachers and expressed my view that teachers' accounts were extremely important. At a subsequent meeting Mrs Cawood said that at first Mrs Roberts was reluctant as she was on a term's leave, but had then agreed. In a telephone conversation Mrs Roberts said she would be very happy to take part in the interview, but she would have to collect her mathematics file from school.

I had observed a demonstration class given by Mrs Roberts earlier in the year, and although, as mentioned earlier, I had not wanted to go into the teachers' classrooms, I felt this teacher was confident enough for that not to be a factor. However, there is a question in my mind whether this factor was not an influence in the interview.

¹⁰ Mrs Print later reported that he had passed the letter on to her, but suggested one of the other teachers take it on as she was so busy. She had however said that as I had approached her informally, she would do it.

Mrs Roberts had 13 years teaching experience in the same school, Nerina Junior school, and was now head of department. This was a small school which included only the first three years of schooling, that is six classes. Mrs Roberts had matriculated with mathematics and science. She had a three year diploma, and had completed a fourth year part-time. She had, prior to teaching, had a job as a buyer for a big company. She had been teaching the "new mathematics" since 1990, that is for five years, at the time of data collection.

The four teachers from House of Representative schools had been implementing the "new mathematics" since 1993. **Mrs Huntley** taught at Swartvlei Junior School. Mrs Huntley was suggested by her subject advisor. I met Mrs Walters, the subject advisor, at an informal talk given by Paul Cobb on the constructivist approach to teaching mathematics. I said that I was doing research on the implementation of the "new mathematics" curriculum, and I was particularly interested in teachers' accounts. I asked if she could put me in touch with teachers who in her terms had successfully implemented the "new mathematics" curriculum. She suggested Mrs Huntley who, although she had retired at the end of 1993, had been particularly successful with the "new mathematics". I phoned Mrs Huntley, explained my interest and asked if she was willing to participate. At the interview it was evident that she had put a lot of thought into preparing for the interview.

Mrs Huntley had been teaching for 31 years in a "coloured school". She taught for 21 years in the Senior Primary, then had undergone further training in the junior primary phase, after which she taught Sub A, then Sub B, but in her last few years of teaching had taught Std 1 and had also been head of department. She had a standard 10 qualification plus a three year teaching qualification. She had implemented the "new mathematics" in her classroom for one year.

Mrs October, Ms Khan and Mrs Joshua all taught at Sea Vista Junior, a former House of Representatives school. This was the second year of teaching the "new mathematics" for the two Sub A teachers, Ms Khan and Mrs Joshua, while for the Standard 1 teacher, Mrs Orion, this was her first year of official implementation. Mrs

Orion had not been required to teach the "new mathematics" in 1993 but had chosen to implement the "new mathematics". She was head of department. I interviewed these three teachers in a group.

It took some perseverance to arrange this interview. I had been given the name of a teacher, Farida, in Sea Vista by a friend who had done some research there previously. Farida, a senior primary teacher, gave me the name of a junior primary teacher, Ms. Khan. She in turn said I should speak to the head of department or the Sub B teacher. At this point I thought a group interview might be appropriate, and suggested it. Ms Khan accepted this idea more readily than an individual interview. I said I would approach the headmaster for permission.

Initially the principal told me the school was too busy and so were the teachers. I emphasised the importance of hearing teachers' views and he consented to me phoning him in two weeks when they were over their busy period.

Two weeks later I phoned Ms Khan and expressed interest in interviewing again. We tentatively arranged a meeting after school one day with the junior primary teachers, on condition that it was approved by the headmaster. I phoned him again. Again he was reluctant, saying that the teachers had been away on courses. He remarked somewhat suspiciously that I seemed to know exactly what was going on at the school when I mentioned some teachers by name! He said he would discuss the situation with the teachers and I should phone him again at 10.30 a.m. that day. I phoned at 10.30 a.m. and he said that he had good news for me, I could meet the teachers at 1 p.m. that afternoon.

The interview was pleasant. I felt a rapport with the teachers, specifically Ms. Khan with whom I had had telephone contact. However, all three, Mrs Orion, the head of department, Ms Joshua, the other Sub A. teacher, and Ms Khan participated eagerly.

4.3 The Interview

In order to address my research question, I decided to conduct semi-structured informal interviews with teachers about the process of implementing the "new mathematics" curriculum and the transition from the 'traditional' approach to the 'alternative' approach. It was my aim to establish a relaxed atmosphere in which teachers could talk about their experiences with the "new mathematics" curriculum.

4.3.1 The interview schedule

In the interviews I planned to investigate the transition process from a "traditional teaching" approach to a "problem-centred" approach which was being implemented by the CED.

This investigation covered two broad areas;

1. The relationship between subject "experts", (teacher educators, education authorities) and teachers, from the teacher's perspective.
2. The changing practice of the teacher involving teaching strategies, classroom management, the learning process, mathematical knowledge and the teacher's role.

However, my interest in the broad areas was whether the theoretical principles underpinning the "new mathematics" curriculum were transmitted to teachers, and whether the teachers were able to talk about the theoretical underpinnings.

Although I had prepared an **interview schedule** (see Appendix A), I did not adhere rigidly to it. In most cases the teachers talked eagerly and spontaneously. Towards the end of the interviews I referred to my schedule to check that all the areas had been covered.

4.3.2 Initial reluctance

There was initial reluctance on the part of the teachers to being interviewed. However, expressing my conviction that teachers' accounts of the "new mathematics" curriculum innovation were vitally important for education, seemed to overcome initial reluctance.

I mention one case which stood out strongly as indicative of a pattern indicating reluctance. Initially there was ambivalence on the part of Mrs Print from the CED project school, River Primary. This was indicated by initial agreement but then a long wait, almost a month, for the interview. However, when the time came for the interview, Mrs Print had obviously taken the interview seriously, reflected on the transition process and was able to articulate her ideas clearly and fluently. The interview, which I initially estimated would take 40 minutes, went on for 1 3/4 hours.

The parting words in this case were;

I would really just say if you can have any influence in any way - I suppose this is just a study for yourself - but if you could have any influence on people is that when they change methods so drastically that they have to have the teachers on their side, listen to the teachers' practical problems on how to keep up with this diversity, how to supply on a daily basis the worksheets that the children have to use, the marking involved.... (Transcript, Mrs P:37)

My contact from Sea Vista, Ms Khan (HOR), was initially reluctant, as mentioned before. As with Mrs Print there was a request from one of the teachers, "I don't suppose you can do anything about this.." ¹¹ She then went on to explain the low status of some of the very experienced, but in the department's terms, inadequately qualified teachers. They were leaders within the school, helping the younger teachers to find their feet. However, after three years the younger teachers received higher salaries. This seemed to be an overriding concern of Ms Khan and her colleagues who were in the interview group.

¹¹ A telephone conversation with Ms Khan after the interview.

I mention these cases as I feel they are indicative of an ambivalence on the part of teachers towards what is seen as "researchers" or people from the university or education department.

4.3.3 The interview situation

The interview situations varied. I left the choice of venue up to the teacher. Mrs Print invited me to meet her in her classroom. I met Mrs Roberts and Mrs Huntley at their homes. The group from Sea Vista I met in the staff room. In each case, I checked whether I could use the tape recorder, emphasising that it was not to monitor them, but to monitor myself and as an aid for recall.

4.4 Comparisons between Schools

While my aim initially was to interview teachers from different schools in order to make comparisons I found I was not able to do this. The different schools were at different stages in the implementation of the project.

A further factor which made it difficult to draw comparisons was that the different schools had very different induction experiences. Mrs Print from the project school, River Primary (Cape Education Department), had three whole day workshops, numerous lectures, and monthly classroom visits. In addition, subject advisors were available for consultation. The other CED school, Nerina Junior School, at which Mrs Roberts taught, had less intense induction, but did have access to documents, and subject advisors were available for consultation. The Sea Vista school teachers, Mrs Orion, Ms Khan and Mrs Joshua, had been to a few lectures, but had had no classroom visits. The subject advisor for the Sea Vista school had taken early retirement and had not been replaced at the time of my data collection. However, the teachers from this school had taken the initiative in working with the local Afrikaans Primary school, where teachers had invited them into their classrooms and shared materials and teaching documents.

The qualifications of the two teachers from the Cape Education Department schools were matric plus a four year training. One of the teachers from the HOR had matric plus 3 years, while the other three had a std 8 certificate, with three years' teacher training. The different qualifications are indicative of South Africa's formerly unequal society and education system. While it was expected that Mrs Roberts would do Science and Mathematics for the matriculation examination, and then go on to further education, Ms Khan and Mrs Joshua were encouraged to leave school in Standard 8 and become trained as teachers, as there was a shortage in the so-called "coloured" schools.

4.4.1 Differences among teachers

Mrs Roberts and Mrs Print, both Cape Education schools, talked fluently and eagerly about the project. At times I stopped them to put one of my prepared questions. In some cases the question was briefly answered but then they returned to their story. After a while, I stopped trying to control the interview, and found anyway that what I wanted to hear was being told. In the case of specific questions to do with theoretical underpinnings there was generally an evasion of the question or an answer which involved the practical application in the classroom¹².

The interviews with the Sea Vista teachers and Mrs Huntley from Swartvlei were much more controlled. In general I put my questions, which they answered. There were, however, moments in the group situation where interaction between the teachers led the interview.

It is possibly significant that my role as researcher was less clearly defined in relation to Mrs Roberts and Mrs Print, as in both cases I had met them before in the role of parent, and would be likely to meet them again. In the case of the teachers from Sea Vista and Mrs Huntley from Blackheath, I would be unlikely to meet them unless a meeting was arranged.

¹² This will be discussed in detail in chapters five and six.

In summary, the differences between the CED teachers and the HOR teachers could be explained as follows;

The CED teachers had been implementing the "new mathematics" for 5 and 6 years, and so had had time to familiarize themselves with it. Additionally it could be that the 'hierarchical' relationship between the 'academic' researcher (myself) and the CED teachers was downplayed, as in both cases these teachers had interacted with me as a parent.

4.5 Summary

For the purposes of this study, I chose to use semi-structured interviews. My sample included teachers from the Junior Primary School, including Standard 1 and Sub A teachers. These teachers were from both CED schools and HOR schools. They were all experienced, competent teachers, who had implemented the "new mathematics" curriculum, and were willing to give accounts of their experiences teaching the "new mathematics".

4.6 Analysis of the Teachers' Guide for Mathematics

The focus of my research was on teachers' accounts of implementing the "new mathematics" syllabus, and through this exploring whether they had access to the theoretical underpinnings of the "new mathematics". In addition to the teachers' accounts, I also analyzed a sample of the documentation on the "new mathematics" curriculum, a file given to me by one of the teachers. I extracted what I considered to be the two central documents. One was the Teachers' Guide for Mathematics put out by the Cape Education Department (1993) and the other A Preliminary Guide for the Teaching of Mathematics put out by the RUMEUS group (Human et al, 1989), although this was not my central focus.

The project school, River Primary, had additional materials which were given out in the initial year. The teacher from Swartvlei had attended lectures at Stellenbosch and had a set of documents which she had received at lectures. The Sea Vista teachers

had collected the CED document, the RUMEUS document, as well as others they had got from the neighbouring Afrikaans school.

I chose the CED document as it was the official guide for teachers, all the teachers in my sample had access to it, and within the scope of this study, it was possible to analyze. I analyzed the document with a view to establishing what the theoretical underpinnings of the "new mathematics" were, the way in which the role of the teacher was constructed, and the way knowledge was transmitted.

In order to clarify some points with regard to the theoretical underpinnings of the new curriculum, and to clarify some points regarding the implementation in schools, I arranged an interview with a subject advisor and had a brief telephone interview with the head of curriculum planning.

Chapter Five

DATA ANALYSIS - THE TEACHERS' GUIDE

5.1 Introduction

My data are drawn from two sources, firstly from the Teachers' Guide which was the official document issued by the department, and secondly from interviews with teachers.

My aim in this research project is to ascertain what access teachers had to the theoretical underpinnings of the "new mathematics".

5.2 Teachers' Guide

The Teachers' Guide for Mathematics: Junior Primary Phase (Cape Education Department, 1993)(TG) is an official document provided to teachers in the Junior Primary Phase. They do have other documentation which includes A Mathematics Curriculum for the Junior Primary Phase: Preliminary Teachers' Guide (Human et al, 1989) put out by the Research Unit for Mathematics Education at the University of Stellenbosch (RUMEUS). These two documents I considered to be the major documents available to teachers. Within the scope of this research, I only focused on the CED document, but do make occasional reference to the RUMEUS document.

In analysing the Teachers' Guide (TG) I focused on my research question, "What access do teachers have to the regulating principles underpinning the "new mathematics" curriculum?" Implicit in the research question are three related questions;

1. How are the junior primary teachers constructed in the Teachers' Guide?

2. What message strategies predominate in the Teachers' Guide?
3. In what form is the official pedagogical practice distributed in the Teachers' Guide? Is it discursively or procedurally elaborated?

While there are explicit statements about the role of the teacher in the Teachers' Guide, the implicit role, the subject positioning of the teacher in relation to the curriculum innovators, will be made apparent in the answering of the above questions.

Access to the regulating principles implies discursively elaborated text in which the theoretical underpinnings, that is theories of knowledge, learning and mathematics are explicitly stated. It also implies an apprenticing of the teachers into the esoteric domain of the "new mathematics" curriculum. The message strategies employed are generalising strategies which enable the teacher to be relatively context independent.

Lack of access implies procedurally elaborated text, a concentration on methodology, teachers constructed in a subordinate subject position, and localising strategies which render the teacher context dependent.

5.2.1 Contents of the Teachers' Guide

The guide includes eight chapters.

<i>Chapter 1</i>	Introduction Some Basic Features of the Problem Solving Approach
<i>Chapter 2</i>	Calculations
<i>Chapter 3</i>	Learning to Calculate through Problem Solving
<i>Chapter 4</i>	Number Concept Development
<i>Chapter 5</i>	Number Facts
<i>Chapter 6</i>	Measurement and Graphical Representation
<i>Chapter 7</i>	Geometry and Spatial Sense
<i>Chapter 8</i>	Media

I chose to focus on the first three chapters as these cover the main issues involved in establishing how the document is put together, how the document constructs teachers, learners and mathematics and the extent to which the theoretical underpinnings are made explicit.

5.2.2 Construction of the teacher

Implicit in the reading of the guide is a construction of the teacher. The teacher "resides within a critical reading of the work" (Dowling, 1993:74). However, before investigating the implicit construction of the teacher residing in the guide, I look at;

- a. the construction of **the learner and learning**
- b. the **role of the teacher** as explicitly stated in the guide

5.2.2.1 The Pupil and learning

Present in the guide are some explicit statements about the innate characteristics of learners, about how pupils learn and about how they solve problems. I have divided these statements according to these three categories. These categories are not set out as such within the Guide itself.

Pupils

- are "active mathematical thinkers" (TG:1).
- "construct meaning" from the "basis of personal experience" (TG:1). In other words they build on knowledge they have already constructed.
- have "valuable mathematical ideas of their own and are able to develop concepts and computational procedures independently" (TG:1).
- have a need for "real understanding of mathematical concepts and computational procedures" (TG:1.2)

The belief that "Pupils' own methods should be valued highly as they are mathematically acceptable" (TG:2.1), sheds light on the Guide's view of learners.

Also present in the Guide are statements about **how pupils learn**. Pupils can "acquire number concept", "basic operations" and "methods of computation" by

- **solving** problems
- **reflecting** on how they solved the problem
- **communicating** how they solved the problem

Children thus learn mathematics through solving problems by thinking about how they solve problems and by taking note of the ways other pupils solve the same problems (my summary of TG:1, Paragraph 3). The problems set for pupils should be "based on real-life situations" with which pupils should be able to identify. It is recommended that the problems be integrated with other subjects (TG:3.1).

While the context of the problems should be within the experience of the child, they are expected to "tackle novel problems without any prior knowledge of how to tackle them. They have to venture into the unknown with little guidance and no certainty that they will achieve success quickly" (TG:3.1). Problem-solving leads to learning of concepts and skill which leads to better problem solving ability which leads to more learning of concepts and skills. What is the role of the teacher in this cycle? How does this cycle move into a spiral?

How do pupils solve problems?

The Guide states that "pupils should constantly experience the freedom to choose methods they understand and are familiar with" (TG:1.2). These methods may be primitive or well developed. However, in the same paragraph it states that "well developed concepts of the four basic operations and a variety of computational strategies, techniques and methods are essential for problem solving" (TG:1.2).

What do pupils require from the learning environment?

Pupils are able to develop these skills given

- "sensible problems" (TG:1.2) to solve independently
- "extensive and well-structured opportunities to think about their own methods" (TG:1.2) through communication with peers.

In the above statements about the pupil, how he/she learns, and what is required from the learning environment, there is a notable absence of a teacher. In the next section I have drawn out statements about the teacher's role. Again these statements were not set out in this way in the Teachers' Guide.

5.2.2.2 *The role of the teacher*

In bold letters on the first page of the Teachers' Guide is the statement, "**No methods of computation should be taught or suggested by the teacher**" (TG:1). This statement together with "Young pupils do not necessarily learn what the teacher attempts to transmit to them directly" (TG:1) suggests that the teacher's role is restricted in particular ways.

The teacher is responsible for the setting of "sensible problems" and for structuring the opportunities for reflection. He/she is also responsible by implication for "the children's perspectives about themselves, about learning and about mathematics" and for the "profound (positive and negative) and persistent effects on their present and future learning" (TG 1.3).

Pupils get a variety of perspectives about themselves, about learning and about mathematics from the way in which the classroom and their learning activities are organised. These perspectives can have profound (positive and negative) and persistent effects on their present and future learning. (TG:1.3)

He/she is required to "remain in full control of the class", but "refrain from interfering in a directive and prescriptive manner with pupils' mathematical thinking" (TG:1.4). Her programme for development includes;

- conducting activities for number concept development
- setting a variety of problems to promote the development of concepts (TG:1.4)

In addition she is required to "monitor pupils' development carefully", "be well informed about each pupil's level of number concept development and arithmetical sophistication". She is required to respond to this by "setting problems and providing appropriate challenges for further development" (TG:1.4).

The following statement that "all new methods (produced by the pupil) should be carefully analyzed to understand the pupil's reasoning and evaluate the progress made by them" (TG:2) points to the role of the teacher as observer, analyst and didactician. The teacher also acts as guide and facilitator. The pupils "should know that they can rely on the teacher (and the rest of the group) for guidance and assistance" (TG:3).

Teachers have to take responsibility for the pacing of their pupils' learning. Teachers "should not try to force their pupils to progress faster" (TG:3.2). Neither should they "underestimate the pupils by giving them boring activities" (TG:3.2). While teachers have the responsibility for conveying social knowledge such as notation and terminology, they are warned not to introduce this prematurely.

....One needs to wait until pupils have had a variety of experiences with the relevant problem types and show clear signs of awareness of repeated addition facts (bold in original, TG:3.8).

She is also cast in the role of note-taker.

Pupils' contributions and reflections on strategies used should be carefully recorded by the teacher (on the writing board) in order to facilitate fruitful discussions, interaction, social learning, comparison and evaluation of the different methods (bold in original, TG:3.2).

In the pupils' own recording of their work, the teacher is to function as counsellor.

The teacher should understand the pupils' computational strategies, and should suggest relevant and effective formats of notation. It would be advisable to suggest the use of the arrow notation for accumulation computational strategies and the "=" sign for partitioning (TG:3.19).

The teacher's responsibility is to expose pupils to **all** possibilities of recording but "has to ensure that pupils, as in the case of computational methods, are free to use the exposition of **their own choice**" (my emphasis) (TG:3.21).

The teacher should guide the pupils in an informal way to refine their computational methods and the recording thereof. None of these recordings should be taught formally or be drilled in order to consolidate (bold in original, T.G. 3.21).

In the above statements, the teacher is expected to take on the role of counsellor to the students. However, the teacher's relationship to established mathematics is unclear, as suggested in the following paragraph;

The suggested format of **recording for a specific method must be functional** (my emphasis). It should not include elements which appear in the context of the method concerned only for the purpose of arbitrary prescriptions without any conceptual function. This will be in direct contrast to the problem centred approach, because **arbitrary prescriptions are only learned through imitation and can only be experienced as authoritarian prescriptions** (my emphasis) (TG:3.19).

Two methods of recording are brought up here, namely "arbitrary" and "functional". The implication is that what is established mathematical practice is "arbitrary", authoritarian and non-functional. By contrast what the teacher is to encourage is functional recording which may or may not be in keeping with the established mathematical body. The dilemma for the teacher in this situation is what criteria does he/she use in order to make the distinction between what is functional and what is arbitrary. It is not quite clear either what meaning the writers attach to "arbitrary". In the dictionary definition (Concise Oxford, Seventh edition) "arbitrary" is defined as derived from "mere opinion" or "random choice". There is another meaning, however, which is "decided by arbitration". It is the second in my view which describes mathematical recording. Neither primary school teachers nor primary school pupils are part of that arbitration process, so whatever is decided by teachers as functional may be condemned as merely arbitrary.

Her role as mathematician, however, is undervalued as she "should not get involved in the mathematical discussions between pupils (except to provide guidance with respect to terminology and symbolism when needed)" (TG:3.25). On the other hand she has an important role to play "in ensuring that pupils communicate effectively and that all the pupils participate in the discussions" (TG:3.25).

Computations are analyzed and four different computational strategies are "explained and demonstrated with relevant examples" (TG:2). The following are the techniques summarised;

Accumulation method "comprises the gradual building up of the answer in a series of steps" (TG:2.2)

To calculate $72 - 38$

$$(1) 72 - 2 = 70; \quad 70 - 30 = 40; \quad 40 - 6 = 34$$

or

...

$$(3) 38 + 2 \rightarrow 40 + 30 \rightarrow 70 + 2 \rightarrow 72$$

Partitioning is based on replacing the original task with a number of simpler calculating tasks (TG:2.2);

Calculate: $346 + 287$

$$300 + 200 = 500; \quad 40 + 80 = 120; \quad 6 + 7 = 13$$

$$500 + 120 = 620; \quad 620 + 13 = 633$$

The **change and compensate** method is often used;

Add $36 + 37$

$$40 + 37 = 77; \quad 77 - 4 = 73$$

Estimate, evaluate and improve is a strategy used by some children.

In addition some computational techniques are explained (TG:2.5). However, the examples are given only in order for teachers "to recognise what pupils do spontaneously" (TG:2.2). In bold the Guide states that "**These methods should not be taught, or even suggested to pupils**" (TG:2.2). Warnings are given should a teacher be tempted to teach methods to pupils.

In the short term, good results could be achieved; but in the long term it will be **detrimental** to the pupils, as they will be deprived of many opportunities to think constructively. They could then experience difficulties when the work becomes more difficult, for example to calculate with decimal numbers (TG:2.2).

While the teacher cannot suggest methods, she is able to guide students when "setting out their methods in writing" (TG:2.2). The **Note** in bold at the end of the chapter again points to the teacher as analyst and didactician.

Teachers should have a thorough knowledge of the content of this chapter in order to distinguish between the various computational strategies used by pupils. This is a pre-requisite for determining pupil progress and to provide for progression and differentiation which is essential for accountable evaluation and classification of the pupils (TG:2.5).

5.2.2.4 Summary

The Teachers' Guide explicitly constructs teachers as facilitators who do not directly impart information, but who are responsible for their pupils' development indirectly through providing the correct environment. The learner is constructed as an active mathematical thinker who constructs his/her own mathematical knowledge somewhat independently. Mathematics is weakly classified, blending with the everyday and subject to pupils' own constructions. However, implicit in the Guide are developmental stages through which pupils spontaneously move.

5.2.3 The production of subjectivity

While the role of the teacher explicitly stated in the Guide is as facilitator and counsellor, her role is in important respects underplayed, even devalued. Implicit in the structuring of the Guide is the positioning of the teacher in a subordinate role. The statements made about teaching are prescriptive and authoritative with little theoretical backing. There is little affirmation of the teacher's present skills or experience.

5.2.4 Distribution strategies

The Guide is procedurally elaborated, without a clearly conceptualised theoretical framework. There have been numerous references in this chapter to statements from the Guide which have dictated procedure rather than given theoretical support. There is reference to theory, such as the types of knowledge identified by Piaget (TG 1.5), namely;

Physical knowledge - knowledge that pupils acquire from handling physical objects.

Social Knowledge¹ - Knowledge that can only be learnt through interaction with people. Mathematical knowledge of this type includes terminology, notation and conventions.

¹ Just a quick look at Piaget's theory of Intellectual Development (Ginsberg and Oppen, 1979:211) throws a different light on social knowledge.

... Because of social transmission, the child need not completely reinvent everything for himself. The culture provides him with extraordinary cognitive tools - the counting numbers, a language, an alphabet. These tools enable him to do mathematics, to speak, to write - in sum, to participate in higher intellectual activities, particularly those of a literate nature (Ginsburg and Oppen, 1979;211).

Logico - mathematical knowledge refers to knowledge that pupils construct themselves by thinking beyond physical knowledge and social knowledge. This is acquired through engaging in appropriate activities (summarised from TG:1.5).

According to the Teachers' Guide these types of knowledge are acquired in different ways, must be catered for separately, and are all required for developing "numerosity"². This information is not contextualized. It does not give any information regarding the origins of Piagetian theory, but states it as though it is an undisputed fact. There is no referencing, or elaboration, (in the Teachers' Guide)³ to allow teachers to ascertain the relevance of this knowledge for themselves. While many of the references can be linked with a constructivist theory of learning, this is not made explicit.

Another reference to theory is the three levels of strategies (TG:3.4) which are identified for addition and subtraction;

Level 1	Counting All
Level 2	Counting On
Level 3	Strategies using decomposition of number

These levels were possibly identified by some research in mathematics education, but there is no reference to the source. Strategies for division problems are also identified;

- Direct modelling: Stage 1
- Direct modelling: Stage 2
- Mathematical modelling: Initial Stage
- Mathematical modelling: Later Stage

² In the Teachers' Guide the term "numerosity" means "to have a feeling for the "how many" of a number" (TG:1.5).

³ There are references in the document put out by the RUMEUS group (Human et al.,1989).

But the warning is given that;

These strategies are not described here in order to suggest that they be taught or suggested in any way, but simply to orientate teachers with respect to what they may observe (TG:3.12).

In the above two cases, where an attempt is made to introduce theory, teachers are not given access to the theoretical assumptions underpinning the theory. Nor are they given research findings or adequate references. For the most part the Guide is made up of what teachers should and should not do. This is in the form of localised knowledge which cannot be generalised across contexts.

5.2.5 Summary

The Teachers' Guide provides limited access to the regulating principles underpinning the "new mathematics" curriculum. By regulating principles, I mean access to the rules which generate the new maths. This is grounded knowledge which is discursively elaborated and which apprentices into the esoteric domain of the "new mathematics" curriculum. Teachers are instead offered sets of procedures, which are disembedded, localised and context dependent. In the latter case, the prescriptions are not grounded in theory and are perceived as quite arbitrary. In the former case, the rules emerge out of the theory, and thus have, in my view, a sounder conceptual backing.

Following from this, it might be argued that for the junior primary teachers not much theory is needed nor much mathematics. This is a matter for dispute and discussion. Theory enables teachers to interrogate their own practice and consequently not be over reliant on external validation. Theory also situates teachers in a dominant subject position which enables them to generalise across contexts, and so base their teaching on relatively few regulating principles rather than on many externally dictated procedures.

Chapter Six

DATA ANALYSIS - INTERVIEWS WITH TEACHERS

6.1 Introduction

In establishing what access teachers had to the theoretical underpinnings of the "new mathematics", as well as addressing the Teachers' Guide, I conducted interviews with six teachers.

6.2 Interviews with Teachers

In my sample there is a wide range of experience of the new approach to mathematics teaching¹. River Primary, where Mrs Print taught, was one of the initial 8 schools selected to participate in the new scheme in 1989, when there was extensive induction. Many lectures and workshops were given to the teachers and monthly visits to the classroom were made by the research team. Nerina Primary, where Mrs Roberts taught, was included in the 16 schools which implemented the new approach in the following year 1990. There was less extensive induction into the approach.

Mrs Huntley's school, Swartvlei, implemented the approach in 1993. She went to lectures at Stellenbosch, and received input from the subject advisor for her region. The other three teachers from Sea Vista, Mrs Orion, Ms Kahn, and Mrs Joshua, have had limited input in the form of teacher support. For example, they attended only a few lectures, and had no visits to their classrooms by the subject advisor from their department² or the RUMEUS group. They have the Teachers' Guides and

¹ See Chapter 4.

² The subject advisor for their area took a retrenchment package, and has not been replaced. Another subject advisor did, however, step in for one lecture.

notes, and had contact with the local Afrikaans-medium school where they observed lessons.

In an analysis of the interview transcripts, I ask three related questions, namely:

Do teachers have **access to the regulating principles** of the "new mathematics"?

Are they constructed in a subordinate or dominant position in relation to curriculum innovators? Are they **apprenticed** into the esoteric domain, or **alienated**?

What is the teachers' **rhetoric** surrounding the "new mathematics"? What, according to their accounts, do they reproduce in their classroom **practice**?

6.2.1 Access to regulating principles

Access to the regulating principles underpinning the "new mathematics" implies that teachers are able to articulate underlying **theoretical principles** independent of the immediate context of the classroom and are able to generalise across contexts.

Teachers have a variety of views about the theory behind the "new approach"? Below is an extract from an interview with Mrs Print.

CJ: Was there ever any discussion about different philosophies of mathematics with the teachers?

Mrs P: No, you were never exposed to a spectrum of philosophies.

CJ: They never said some mathematicians believe this and some mathematicians believe that.

MrsP: It was an alternative method

CJ: Because this alternative method is based on a philosophy of mathematics.

Mrs P: Yes, I don't know whose philosophy it is based on. I actually... when we went to that very first meeting that I told you about, where we are supposed to have discussed calculators. O.K., and he gave us some pamphlets. I have still got them, they are excellent pamphlets and I realised the following year, a year later when they started this new

maths thing, that all the new maths had come out of these pamphlets without a doubt. There were only a handful of teachers at that meeting. It was such a pity.

CJ: At that first meeting.

Mrs P: It was that meeting about calculators. ... I was absolutely thrilled, because what he had been saying made perfect sense to me and it is what has been missing in education all along, the children aren't allowed to think for themselves. I was so excited that I couldn't sleep the whole night, that is how excited I was about that meeting.

CJ: But what was explained at that meeting didn't come up again.

Mrs P: No it didn't come up again. Then it became the RUMEUS team theory as to how maths should happen in the schools.

CJ: But no underlying..

Mrs P: No, there was no broad philosophy. No exposure to what Piaget thought or what somebody else thought or what Rudolph Steiner thought or what Montessori thought. You got told nothing like that, you were just told, we want children to think and this is what we were given, this was the recipe (Transcript Mrs P:27-28).

(Mrs Print then brought out a sheet of paper on which were the following points outlining teacher practice. The following was the "recipe".)

Challenge the pupils to do one of the new sums. This is the story sum. Posed in the form of a real life problem story sum. Allow primitive degenerative methods of computation.

Let pupils share their methods in small groups.

Display the methods used by the pupils, starting at the more primitive ones in the class.

Pose more sums in the form of real life problems. Allow them to use primitive methods and gently prod them to use more sophisticated methods (Transcript Mrs P:2-3).

The following extract is a further example of my attempts to probe for teachers' access to the theoretical underpinnings;

CJ: But I mean some of these things that were told you, that you were not to send them back without

- Mrs P: them being satisfied
- CJ: And that you are not to give them methods. Was there a reason behind that?
- Mrs P: Yes
- CJ: Did you have the reason behind that? Did you have reasons behind those particular things.
- Mrs P: The reason first of all was that they didn't want any method to be subscribed, that was the basic thing, and also to help you to establish where they were at, were they at the...different levels...
- First of all there is the Counting All, that is the primitive. Then they start Counting On, at least they know the starting number. They have got it, they don't have to break it up to establish what it is. Right, if they have got 25×4 , they know that they have got 25 once now they just have to add 25, 3 more times, so that was the second thing.
- And now the third thing, Then they get to the Replacement Level where they are actually decomposing the numbers, they are beginning to realise that 29 is $20 + 9$ AND 46 is $40 + 6$, so they have got to deal with 20 and 9 and 40 and 6, they don't have to deal with every little counter that makes 29.
- CJ: Now you haven't told them that.
- Mrs P: No they just find that out of their own accord. You don't teach them base ten at all. They just realise when they write the number 29, it's meaning also.
- CJ: They haven't...
- Mrs P: They have never been taught is.
- CJ: No, they have got to discover it.
- Mrs P: Discover it. So the reason for allowing them was that they didn't want the teacher in any way to interfere, or to prescribe the method, or the solution, or in any way tell them that what they were doing is wrong if it was legitimate to their thinking, to where they were at in their development. (Transcript Mrs P:8-9)

The different levels relating to computational strategies were what this teacher saw as underpinning the new curriculum. The three levels related to some research into computational strategies. However this research was not referenced.

In the other interviews, although I attempted to draw teachers on to the topic of principles and ideas about the basis of the new approach, I was usually steered back towards classroom procedure. In an interview with Mrs Roberts, she interprets principles and ideas into classroom procedure;

CJ: Were you given the principles, the ideas.

Mrs R: Mrs Davids (subject advisor) actually came into the classroom and watched me teaching... No .. put it this way, Mrs Davids came into the classroom and she asked you what problems you were having and had you tried it and how was it going. She is a lovely lady and full of concern, full of encouragement. If you said I'm actually battling, I don't know how to do this. I'm not quite sure if I am doing my multiplication correctly, so she would say, "Let me show you some methods", and she would take them on the mat and she would give you ideas (Transcript Mrs R:20).

When Mrs Roberts expresses problems, the response from the subject advisor is in terms of method rather than theoretical explanation. The subject advisor takes over the class and demonstrates methods. Here is another example of the probing for theory eliciting a response in terms of practical application.

Mrs R: ... That is another thing, the apparatus keeps changing, you don't keep using the same thing.

CJ: Do you encourage them to use different apparatus.

Mrs R: Yes

CJ: And the reason behind that?

Mrs R: Well for example one of the things you do is put out a whole pile of buttons, and you ask the child to see five, they pull out five. Now if the child is counting in fives, you can take little piles of five, but isn't it easier if they have got unifix blocks... it's incredible how they learn.... they're (the unifix cubes) in blocks of ten, so they will break it in half,

or they realise that ten is five doubled, and all these sorts of thinking strategies that you have never done before start coming out (Transcript Mrs R:6).

Her reason for changing apparatus is supported by her classroom practice, not by theory. And in another extract from the same teacher;

CJ: We talked about the different understanding of maths...

Mrs R: Now you see your understanding of maths are those different levels of thinking (Transcript MrsR:25).

The different levels of thinking are cited by the above teachers as the theory on which the "new mathematics" is based.

6.2.2 Apprenticeship or alienation

Access to the regulating principles underpinning an activity implies an **apprenticeship** of the subject **into the esoteric domain**, in which case the subject is able to draw on the regulating principles to organise and interrogate his/her practice. Limited access to the regulating principles renders the subject reliant on procedure and essentially alienated from the esoteric domain. This implies a **subordinate position** in relation to those who have access to the esoteric domain as it is from the esoteric domain that the activity is regulated.

The teachers in my sample were inducted into the "new mathematics" curriculum through lectures, formal meetings and reading material. The teachers from Sea Vista said that lectures were not at all helpful. "It's talking and talking, and you follow it through the pages. Now you don't actually know what is going on" (Transcript SV:15). They felt they had been fortunate in that they had had contact with a school where the new approach was being implemented. However, some of their colleagues were "still in the dark" because they had not observed the approach. They also felt that the notes were unhelpful (Transcript SV:19). Ms Khan had the following to say about lectures;

Ms K: They also give you too many notes, with the result that you don't feel like reading all those notes. You want to see as Joan says...you don't want to go through all those notes (Transcript SV:19).

Mrs Huntley from Swartvlei had her notes from the courses she had attended at Stellenbosch. "I've been to the lectures, read the material, now it is up to me" (Transcript Mrs H:13). At the lectures she got moments of inspiration, but when she got back to her class she found that what she thought would work did not. She explained this as lack of mathematical background on the part of the children.

Mrs Roberts, from Nerina Primary, said that everything was in the Teachers' Guide, but she "didn't think this was good enough for planning...I actually sat down and went through the syllabus and the handbook and I worked out a programme of maths for Standard 1" (Transcript Mrs R:6-7). Mrs Roberts had recontextualised the Teachers' Guide into a working document from which she could teach.

River Primary, the school at which Mrs Print taught, was one of the eight initial experimental schools in the Western Cape. They had extensive workshops and lectures. She reports that in those lecture workshop situations the teachers never spoke up about what the problems were;

Mrs P: ...and when we used to go to these discussion groups in the third year, I started criticising a couple of things because I felt we were getting into trouble. But most of the teachers sat there tjoepstil (dead quiet), and they needed... to be in with this thing.

You actually had to subscribe to his way of thinking. O.K. And it was also kudos stuff, not actually having the integrity to stand up and be counted and saying, well either I've got it wrong, in which case my maths education - I need to be reeducated - but this is what I am actually experiencing in the classroom.

A lot of them couldn't articulate that. They hadn't been long enough in the class, they had no yardstick, O.K.

And I said to him, I've been in the class for, at that point 25 years anyway. What I am actually finding and what I am beginning to get very unhappy about is ...(Transcript Mrs P:25).

While the teachers generally had access to lectures or lecture notes, these were for the most part unhelpful. Mrs Print found them confusing. Mrs Roberts organised a programme for herself in order to facilitate her teaching. Mrs Huntley, although she had been to lectures, felt that she had to read all the documents issued by the RUMEUS group, of which there were at least ten, in order to get to grips with the new approach. The Sea Vista teachers got their help from colleagues at the local Afrikaans-medium school. From the above, it appears that these teachers have not been apprenticed into the esoteric domain through the induction process. Their understanding of the theoretical underpinnings remains unclear. In general the transmission from subject advisors and the RUMEUS group has been in the form of procedures rather than theoretical principles. This constructs the teacher in a subordinate role in relation to the implementors of the curriculum.

Mrs Roberts describes the subject advisor as "wonderful", supportive and accessible. However, her input was not in the form of theory or principles as is evident in the following extract which was quoted previously;

CJ: Were you given the principles, the ideas?

Mrs R: Mrs Davids actually came into the classroom and watched me teaching... No .. put it this way, Mrs Davids came into the classroom and she asked you what problems you were having and had you tried it and how was it going. She is a lovely lady and full of concern, full of encouragement. If you said I'm actually battling, I don't know how to do this. I'm not quite sure if I am doing my multiplication correctly, so she would say, "Let me show you some methods, and she would take them on the mat and she would give you ideas.

CJ: Then did you team teach that way.

Mrs R: And then they gave the teachers all sorts of other... apart from the word problems which they expect you to put in at the different levels...have you seen this... very, very important. The concrete aids... (Transcript, Mrs R:20)

The subject advisor, Ms Walters, introduced Mrs Huntley to the new approach. Again the emphasis is on procedure.

Mrs H: She gave demonstrations how to go about introducing the maths, how the teacher has to act and how the pupils have to act and so on.

Mrs Print had visits from the research team in the first two years of the implementation. Again the relationship is hierarchical and the information transmitted is authoritatively stated.

Mrs P: Now the very first year Prof. Holmes (not his real name) came into my classroom and we were teaching the maths. Mrs Davids was so anxious that he came into my classroom because she thought I was so flexible and I did all these exciting things. And at that stage I really was. I was very behind everything we were doing and he said, "No, No, " I was using Cuisenaire rods (Transcript, Mrs P:23).

She goes on to explain how she used concrete aids. She made extensive use of them. In the new approach aids like Cuisenaire rods which are pre-grouped are not acceptable. The idea is that the children have to form their own groupings. However, the theory underlying choice of concrete aids was not explained to Mrs Print, but authoritatively stated.

And then back to Prof Holmes;

Mrs P: And he said they have got to think all this in their heads. O.K. So I said to him... I had to think very hard about that one, but I thought to myself, "Maybe he is right." I was quite open to the suggestion that he could be right. O.K. I would say to them use the aids if you need them.

Now he was right for the child who had reached level 3, O.K. and that meant the child could decompose. The child had somehow established this for himself. He had his own number system, his own number line in his head and he was counting on a number line in his head already. He had an inbuilt calculator but he was certainly not right for the middle group and he was not right for the lower group. At least that's what I have concluded in the fifth year of this teaching experiment.

When he came in that first year he told me he loved what was happening but it was too concrete. There were too many concrete aids, he wanted them to use this calculator in their head. So I thought O.K. I'll go along with this, so you see I was really a bit....a bit...what's the

word I want to use. He sort of confused me because I had been in the classroom long enough I should have been able to stand firm on what I had already discovered in the classroom. and I thought to myself, "This is a new way" and I fell for this hook, line and sinker. O.K. I thought yes he's right he knows more about this, you know he is a maths professor, he must know more about maths than I do, so I succumbed to social pressure there. And I thought to myself he must know more than I do, I'll go along with this, and you know it was really... it didn't take me too long to discover that the group that we had in our third year, our first year (of teaching new maths), had had two years of basic traditional maths, and that is why they succeeded so well, and the group we had in our second year had one year of traditional maths, and the group that came in the third year had no traditional maths at all and that was the year we started getting into real trouble (Transcript Mrs P:23-24).

Prof. Holmes had access to all the research and the psychological theories. He had re-contextualised this research into a new curriculum. But he failed in this case to convey the underlying theory and he transmitted procedurally elaborated text to the teacher. This precluded her from integrating the theory into her whole style and approach to teaching.

6.2.3 Rhetoric versus Practice;

Brown (1992) warns that the rhetoric surrounding "good practice" is rarely helpful to teachers. An alternative would be to "found our activity on shared sets of underlying principles" (Brown, 1992:39). What practices are reproduced by the teacher according to the teacher's accounts? In this section I attempt to answer the following questions;

- a. Is the **role of the teacher** as set out in the Teachers' Guide congruent with the teacher's accounts of her role?
- b. Is the **construction of the learner**, given by the teacher, congruent with the Teachers' Guide?
- c. Is the teacher's understanding of **mathematics** any different in the "new mathematics" curriculum?

6.2.3.1 *Role of the teacher*

Mrs Huntley talks about a changing role for the teacher. In the new approach, "I mean you're not teaching...", meaning that she acts as a facilitator. However, when talking about her own teaching, "you've got to explain things over and over again", she experienced the teaching as more intense, "because you've got to watch every single child to see how they progress", and there is more interaction between teacher and child.

While the teachers at Sea Vista know the rhetoric, "... the teacher is actually the facilitator and the child is sort of in the driving seat" (Transcript SV:3), they acknowledge that there are things that you must teach. If a child doesn't know something you must teach. Also if he doesn't learn the traditional methods through indirect means, there are "ways and means of coaching him" (Transcript SV:6).

Mrs Roberts states quite categorically at the beginning of the interview "The teacher is now a facilitator, you do not teach maths" (Transcript Mrs R:5). She talks about "her actual teaching, or facilitating" (Transcript, Mrs R:7) that she does on the mat. Here is a clear example of where the rhetoric surrounding the "new mathematics" and the teaching practice clash. There is no doubt that Mrs Roberts teaches when the children are on the mat. She is in control, she is directing operations, and the focus is on her³. But in order to retain her status as a good, "progressive" teacher she needs to use words like facilitate. This is again evident in the following statement, ... "and then what you are supposed to do, which takes an awfully long time... Every child is given a chance to explain what he has done and how he got his answer..." (Transcript, Mrs R:11). She then goes on to explain a strategy she uses;

Mrs R: Invariably you choose a child who got the answer right...You say, O.K. explain how you did that, O.K. who else got that answer? How did you do it? anyone not get that answer?
Now let's see what you have done. You don't say to the child you're wrong. What has he done that somebody else hasn't

³ Mrs Roberts was the teacher I observed in April, 1994, at a demonstration lesson.

done, Has he forgotten something? Ah, I see where I've gone wrong or whatever. O.K. Let's try another one (Transcript Mrs R:11).

At another point she relates an account where she gets the whole group to practice a method she perceives as efficient. She has incorporated some aspects of the new approach, namely that children construct their own knowledge, but she also has a clear idea of where they have got to get to mathematically and she intends to get them there.

Mrs Roberts gives her whole class an extensive and thorough test in June of their Standard 1 year, but this contradicts the new approach. "Now I use the word test very cautiously because in Junior Primary we do not do tests" (Transcript, Mrs R: 23). By testing she can ascertain exactly what they know and what they do not know. She then works out worksheets based on the results and in addition distributes them to her colleagues. Her assessment is directed at the mathematics that the child knows and not at the child's internal developmental attainment level.

For Mrs Print "it was through the children's methods that you did your teaching. You bring the degenerate methods up to sophisticated methods" (Transcript Mrs P:23). However in practice this process became a circus.

Mrs P: ...and they said it didn't matter how long it took them. We had to actually stay with them, and they said we shouldn't send them back to their desks unless they felt perfectly satisfied that they had solved the problem. Because otherwise we were going to create great psychological problems or frustration in the child who hadn't been able to finish his sum.

CJ: Is that in the old days?

Mrs P. No, this is in year two of this experiment. This is the alternative maths.

CJ: This is the alternative.

Mrs P. So in the alternative maths we are being told don't send them back until they have finished their...

So you see I divide my board into 12 spaces, the spots are there, and each child stands in front of a designated area like this O.K. This is his space (shows me on the board) and there's his chalk and he writes his solution and he gets lower and lower and he writes it to the bottom, and then he goes and sits on the mat and watches what everyone else is doing.

So what we did was.. we weren't allowed to time them, we had to give them as much time as they liked so they felt comfortable, and we had to watch, and start choosing the samples we were going to use for discussion basically O.K. so they sit there, now you've got to ... and you find this child has used up (laughing) his whole space of his board, the time has gone, he has gone on for something like 45 minutes, and you have got 55 minutes for maths and you are doing group 1. O.K. because his method is so degenerate, I mean they really are. They are so primitive, his methods are so primitive. It is taking him forever, it is like long ago man counting all his stones, it is taking him forever to get to the solution... (Transcript Mrs P:7-8).

While the role of the teacher is supposed to be that of facilitator, and not to teach directly, it appears in the teachers' accounts that they find difficulty implementing this. They pay lip-service to the rhetoric surrounding the teachers' role, but according to their accounts they need to teach.

6.2.3.2 Construction of the learner

Mrs Huntley espouses the rhetoric that "children must learn at their own pace" and that the teacher should not teach computation methods directly. However she tells the children "We can't sit here the whole day" (Transcript, Mrs H:11), and points out another child's method which is quicker.

In the new maths the child works out his/her own method, which he then has to communicate to the teacher. Ms. Khan at Sea Vista reports that the children have a lot of trouble communicating what they have done. This aspect of the new approach does not quite fit with her experience in the classroom.

Mrs Roberts says "every child goes at his own pace" (Transcript Mrs R:4). This is part of the rhetoric. In practice Mrs Roberts "keeps them on their toes" (Transcript, Mrs R:10). The weak ones she puts next to the bright ones, so that the brighter ones

can teach the weaker ones. "It's good for both of them. And it teaches cooperation" (Transcript Mrs R:8).

Mrs Print says the experimental team are out of touch with the classroom situation and the child, presuming too much self-sufficiency on the part of the child. The top group children "are flying", but the bottom group and the middle group are struggling. In general the teachers at the four schools acknowledged that the new approach had highlighted greater capabilities on the part of children than they had previously thought.

6.2.3.3 Mathematics and the teacher?

Neither the "new mathematics" Teachers' Guide, nor the other documentation to which the teachers have access have made explicit whether a different philosophy of mathematics underpins the innovation⁴. However, the approach to teaching mathematics advocated in the "new mathematics" curriculum seems to conflict with the teachers' understanding of mathematics as a discipline and as facts to be learnt. I focus on teachers' understanding of mathematics, their attitude towards mathematics, and various problems relating to the mathematical content as a crucial indicator of access to the regulating principles underpinning mathematics.

For Mrs Roberts, the major change in her practice is that now "the child understands what he is doing" (Transcript Mrs R:16). The children know what they are doing and why they are doing it. They are working within an increased number range and for the most part at an accelerated pace.

A great deal of the mathematics in the "new mathematics" stays the same. Mrs Roberts expects that the children will revert back to the "traditional" ways sooner or later. In fact her understanding of the new approach is that it offers easier access into the standard mathematics algorithms.

⁴ See Chapter 3 Theory.

For Mrs Huntley, "the maths is still the same", however you get there (Transcript Mrs H:13). This statement clashes with the notion that mathematics is individually constructed, with each pupil using his own method. In her classroom practice, though, the former statement holds true.

CJ: O.K. So how do you assess whether a child is learning mathematics.

Mrs H: By giving them a problem, and they are able to solve it.
And obviously, you are not going to stick to their methods all the time, because they are going to draw. You are going to point out, "Isn't there going to be a faster way of doing it".
And eventually, once they have an understanding of solving problems you can say - if they don't know the traditional method - "Here's another way of doing things."

CJ: So you can show them the traditional method as another method.

Mrs H: I think that's the aim of also getting them to the traditional method as well (Transcript Mrs H:10).

The teachers at Sea Vista agreed that this new maths was about teaching "thinking skills". Mrs Orion felt that "it is basically the same thing but little things that's opened up to us" (Transcript SV:6). The main change is that the children work within an increased number range, they "worked at their own pace". However, there were still things they had to know and had to be taught.

Mrs Print felt strongly that children had to understand "the language of mathematics" before solving problems. "And the language of mathematics is number concept" (Transcript Mrs P:26). This new method "is like inspanning the cart before the horse" (Transcript Mrs P:26). She compared mathematics teaching with language teaching where she made sure her children had the language tools necessary before she set them an essay.

The teachers held various **attitudes** towards mathematics. Mrs Roberts loves mathematics. She loved algebra in matric. She has taken hold of the different mathematics concepts required in Standard one and incorporated them into a

thorough teaching programme. Mrs Huntley loved maths. Both her sons were doing Engineering at the University of Cape Town. She reported that she spent hours doing maths with them when they were younger. Two of the teachers, Mrs Joshua and Ms Kahn, were excited by the new approach. Ms Kahn liked the variety of activities they did in the class. She found data-collecting interesting. Mrs Print loved mathematics, was very excited about the new approach originally, but that has waned, as the practice hasn't met her expectations.

Various **problems** in connection with implementing the "new mathematics" were raised during the interview. Mrs Roberts expressed the need for help in the form of student teachers. She also made special effort to find time outside normal teaching time for the 'slow' children.

Mrs Huntley's worry was whether her pupils would cope with going back to the traditional approach. Her concern was with teachers who didn't understand mathematics and would mark a child wrong when in fact the child was right. Mrs Huntley came across as an extremely capable and enthusiastic teacher with a good grasp of mathematics and an understanding of the regulating principles of the new approach. However, she had only taught for one year before she took early retirement.

The teachers at Sea Vista felt insecure about their own mathematics ability. Mrs Orion expressed the need for more thorough preparation. She checked beforehand on whether she could solve the problems which she gave to the children. She mentioned a situation where she was lost as far as the maths was concerned, but elicited help from the student who was doing practice teaching in her class.

Mrs Khan did a complicated problem with her Sub A class⁵. They eventually arrived at the answer which was part way there, however not entirely correct. This teacher (she had left school in Standard 8 to follow a teaching career, but dropped maths in Standard 6) expressed a concern that while they thought what they were doing was correct, they had never been evaluated so she didn't know.

Mrs Print seemed to be confused about the mathematics involved in the "new mathematics". There had been a directive in the RUMEUS document that indicated that teachers were to abandon "the numbers of tens, numbers of units interpretation of two digit numbers and the associated pedagogical devices" (Human et al., (1989:1). She had interpreted this as a directive not to work with base ten. While the pupils' "own methods" were, according to the CED document (1993:2), "mathematically acceptable", it is obvious from the examples that she uses that their strategies were leading them around in circles.

Mrs P: So in the traditional method, if I said to the children, 29×3 they knew what multiplying means, they said 3×9 are 27, 3 2's are six, seven eight, so that even if they made an error in the total, it was easy to correct the formula.

But now when we are doing 29×3 and the child is having to break 29 down 3 times and he is saying $20 + 9$ and he gets 29, and then he says $+ 20$, now hopefully that sub-total is going to be right and he is going to be able to say 49, now he has got to remember he has still got to add the three (Transcript Mrs P:11).

6.2.4 Summary of Interviews

In summary, all the teachers contradict the rhetoric surrounding the "new mathematics" about their role as teachers. Mrs Roberts is quite clear about the difference between what teachers are supposed to do and what she actually does. She has an understanding of what procedures are expected of the teacher and what

⁵ The problem; If ten children each had a turn swinging around with each other only once, how many swings would there be in total. They had succeeded in demonstrating it practically, and had worked out the answer as 90. However they had omitted to divide by 2. I later demonstrated a method for solving that problem with hints from John Mason's *Thinking Mathematically* which she eagerly accepted.

is expected of the pupil. However, in her practice she finds that certain things "work". She recognises what the "new mathematics" requires and is able to put into practice a hybrid which works for her. It includes aspects of the "new mathematics", the content, concepts and ideas. But what it does not include is the weak classification of the teacher's role.

It is interesting that Mrs Roberts is teaching at a small school, six classes from Sub A to Standard 1. In an informal talk with the principal, she said that she gives her teachers a lot of freedom. She likes to see her teachers' preparation, but does not prescribe in what form it is. The principal herself has quite a good standing in the field of Junior Primary Education. These factors among others form a supportive environment for Mrs Roberts, which is relatively free of external control.

The Sea Vista teachers, who have only recently implemented this approach and have had relative autonomy in their teaching practice, have incorporated some aspects of the new approach. Ms Khan has included data collection as an exciting addition to her teaching practice, while Mrs Joshua has included problem-solving in her Sub A class. There is some confusion, however, as to what the "new mathematics" involves. Mrs Orion felt that word problems phrased in a more complex way constituted "new mathematics".

Mrs Huntley, as in the case of Mrs Roberts, is able to articulate the rhetoric surrounding the "new mathematics". She has incorporated aspects into her teaching such as more interaction between the teacher and the child, and between children, although she had always liked interaction, it was the way she "operated" (Transcript Mrs H:10). In her case she chose to implement the "new mathematics" in her Standard 1 class and was able to draw on support from her subject advisor.

Of all the teachers interviewed, the new approach had the greatest effect on Mrs Print. The reason for this, in my view, was that her school was part of the initial 8 experimental schools. She had researchers in her classroom every month monitoring what was going on. The relationship between the researchers and this teacher was

hierarchical. Mrs Print admits to being impressed by one of the research team who she assumed must be a mathematics professor, and feels in retrospect that she should have known better, and trusted her own judgement and years of experience.

The interviews with teachers indicate that they have limited **access to the regulating principles** of the "new mathematics". They also indicate that they are essentially alienated from the esoteric domain knowledge which supposedly underpins the "new curriculum". They are constructed in a subordinate rather than dominant position in relation to curriculum innovators. And thirdly, teachers' **rhetoric** surrounding the "new mathematics" is not, according to their own accounts, reproduced in their classroom **practice**.

Chapter Seven

DISCUSSION AND CONCLUSION

7.1 Summary of Data Analysis

Interviews were conducted with the teachers in order to ascertain whether they could articulate the theory underpinning the "new mathematics" curriculum. An analysis of the Teachers' Guide was done to see to what extent the theoretical underpinnings, that is a theory of learning, a theory of knowledge and possibly a philosophy of mathematics, were made explicit.

From interviews with teachers it was found that in general they were not able to articulate the theory underpinning the new approach. They had not been apprenticed into the esoteric domain. Their knowledge base remained at a procedural level and was context-dependent. While the teachers could espouse the rhetoric surrounding the "new mathematics", this was not integrated into their teaching approach. Where a teacher tried to implement the procedures "by the book" she found they did not work and her classroom became a "circus" (Transcript Mrs P:19).

The Teachers' Guide includes statements about pupils, how they learn, and the role of the teacher. Implicit, although not directly stated, is a view of mathematics as socially constructed. These statements may or may not exhibit theoretical coherence, and in general were stated categorically without any theoretical base. Where there was an attempt to introduce theory, the theory was introduced out of context. Ironically, the two isolated bits of theory included in the Guide, the different types of knowledge, from Piagetian theory (TG:1.5), and the computational strategies (TG:2.2) through which pupils supposedly proceed developmentally, were taken up by the teachers, who tried to make sense of them in their own teaching (Transcript Mrs P:9, Transcript Mrs R:10, Transcript SV:21).

Implicit in the Teachers' Guide is the subordinate subject positioning of the teacher. The style of the document included authoritative statements, with no reference to theoretical origins. The previous teaching style and experience of the teacher was essentially annulled as having been disproved through research (Human et al. 1989:2).

Without access to the regulating principles of the "new mathematics", teachers must necessarily resort to what works for them in their classrooms, incorporating some elements of the "new mathematics" but only in so far as these elements fit the theoretical framework which is already in existence for the teacher.

7.2 Possible consequences of limited access to the regulating principles underpinning the "new mathematics" curriculum

The official pedagogic practice, as it is transmitted to teachers, withholds access to the regulating principles. There is a question whether there is a coherent set of principles regulating the activity or whether the document is a collection of "good practices". But given that there is no theory to support the practice, what are some of the forms of control as reflected in the teachers' accounts, which ensure the implementation of this new curriculum?

7.2.1 Forms of control

There are implicit forms of control that can be detected in teachers' accounts and are not the explicit intentions of the curriculum designers. The themes which were raised in the interviews were fear of harming the child, comparisons with other teachers and the myth that everything that had gone before was of little worth.

Fear of harming the child

In both the Teachers' Guide (CED, 1993:2.2) and the RUMEUS document (Human et al., 1989:D1) there are warnings given of harmful consequences should certain procedures not be carried out, or certain teaching strategies carried out. The teachers also express these concerns. Mrs Huntley is insistent that you "do it the

proper way. The teacher can confuse the children" (Transcript, Mrs H:8). As was mentioned before Mrs Print was warned that they would "create great psychological problems or frustration in the child" (Transcript Mrs P:7) if the child had not been able to finish his/her sum.

Comparisons with other teachers

Another control technique involved holding up successful teachers as examples of how things should be done, and thereby implying a lack or deficit on the part of those teachers for whom the new system was "not working". The silencing of teachers who felt their reputation as teachers was at stake should they expose their difficulties was reported in teachers' accounts. Mrs Huntley reports that other teachers are "uncertain themselves about this new approach" and they "don't know what to do" (Transcript Mrs H:11). Her own attempts at helping colleagues were unsuccessful.

Mrs H: When we have discussions, they agree with me, they understand, I call them to my classroom, show them what the children can do, take them to the Sub A's who are busy with the work. They simple love the maths that's being done, but when they get back to their own classes... it is a different story (Transcript, Mrs H:5).

A **myth is perpetuated** here that everything that was done before was bad or lacking, that "traditional teachers" taught by rote and did not interact with children. Mrs Huntley states that in the new approach there is much more interaction between the teacher and the child. In the past there was only rote learning. However, when talking about her own teaching, an interactive classroom is what she claims she always had, "I liked interaction" (Transcript Mrs H:10). There is a part of the myth which states that teachers now understand the child's thinking whereas formerly they did not.

Mrs Roberts also, in my view, colludes in the myth of "What was done before was bad".

Mrs R: ...Before you never took the child... as far as I am concerned, the child was never really considered. I know it sounds very harsh to say that. We certainly taught in our groups, you considered your weak child and you considered your above average child, and try and let them go on, but you never actually tried to get inside the child's mind to find out how the child was thinking, tried to see their logic, tried to see how their heads work. That's basically the difference and before you would teach a child something, you would say to the child, "No, that's wrong". You would show the child how to do it the right way, and expect the child to do it that way (Transcript, Mrs R:15).

7.2.2 Criticisms of the implementation and reports regarding other teachers

Mrs Orion at Sea Vista reports that in general the teachers are unprepared, "in the dark" and don't know how to teach the new approach. She feels that if there was more discussion the teachers would feel more a part of the project.

Mrs O: There's never group discussion with teachers when teachers are asked about a certain method. We are just told. Or do you have some input, or do you have a different method. It always comes from the top. Although the subject advisor does tell us, "In your class you can do your own method - what you think works in your class. You are allowed that little freedom, you know". That is why some schools can say they are not doing it but there is nothing that comes from the ground. It's always from the top.

CJ: O.K. What would be a better way of doing it. If you were subject advisor.

Mrs J: If we all had equal...

CJ: If you're all recognised.

Ms K: For your contribution

Mrs O: And like I say prepare the teachers well before the time. And in that time teachers can also give input. And then at least you will also feel that you are part of it. There is never anything that comes from us at all. It always comes from the top. That is why some teachers, who have been teaching 20 to 30 years can say they come up every time with something new, and you just have to follow. We followed for two years, and then they leave that, then they come up with something different again. The teachers are really saying, "Look here we are not going to do anything of this now, because you work for a two years and it's gone." There's no follow-ups and they feel it is just a waste of time,

so they will teach the way they were taught at college. Because they do start a thing and stop (Transcript SV:18).

Mrs Roberts has heard from colleagues, not teachers at her own school, but others that teachers are resisting this new approach.

Mrs R: At some schools, I have heard from colleagues, I haven't come across any myself, but some of the older teachers weren't that keen. Because, let's be honest, it's work. And you have teachers who are dedicated, and you have teachers what they taught on day one of their teaching careers, are teaching on day one of their thirtieth year. (laughs) Some people are afraid of change. So I think it is very important... (Transcript Mrs R:17).

And she goes on to talk about what she does in her class. Mrs Print reports that teachers are resisting. She felt they might have been transformed if the practice had worked but for many of the teachers it was not working. In general the teachers thought mathematics was a discipline and there was an economical way of doing things and this new approach to mathematics was just a waste of time.

Mrs P ...even to this day because we are now into the sixth year of new maths and there are still teachers fighting it and wanting to go back to the traditional maths. O.K. and some of their points are valid, some of their arguments are valid. I mean they fought it right from the beginning, in other words they didn't become transformed during the process through watching the results.

And I think that you know teachers have got to do the job everyday. And for a teacher the main thing is that when they leave the day they want to feel that morally they have done what was expected of them, that those children have been taught, and for a real teacher - for a true teacher - that is absolutely critical. If you get into bed at night and you are fretful and you think oo gosh I haven't got a clue what is going on there and it is not going. I just know it's not happening and it's all wrong and then you start getting tense about it, well it's only going to build up into a state of absolute frustration until you hate it and then you get frightened of it and you run away from it. Now there are quite a percentage of teachers to whom that applies and they have done maths themselves at a matric level, and they were not liking it. They were not liking the freedom, they felt maths was a discipline. O.K. and they felt that there is a way to achieve something quickly,

CJ: So their view of maths was that it was a discipline.

Mrs P: Yes it was a discipline and you see..

CJ: And the view of maths now seems to be different.

Mrs P: Yes and I think they would have been transformed if the practice had been successful but because the practice wasn't successful it consolidated their stand that "maths is a discipline stand" and there is an economical way of doing something and it is the economical way you teach, You don't let children go through these phases of "Counting All" which is a waste of time, which they could see was a waste of time. It was a waste of time because a child wasn't succeeding at it (Transcript Mrs P:15).

7.2.3 The "halo effect" in the experimental group.

The school Mrs Print taught at was one of the "chosen" schools. The "halo effect" refers to a phenomenon in research whereby an experimental group by virtue of being under the spotlight will show improvement, whatever the method used. It appears from this that Mrs Print's account that being chosen as an experimental school meant that the mathematics was perceived as being improved while under the spotlight but whether this renewed enthusiasm could be sustained involves further investigation.

Mrs P: O.K. Now this was the theory and this was what they hoped would happen. And in fact they informed us in no uncertain terms that it would happen. It was as absolute as that, it would happen, and it wasn't the children who were retarded it was the teachers who were retarded. We were left in no doubt although they said it very politely (laughs) and very nicely, (laughs) we were left in no doubt that it was the teachers who were resisting the thinking not the students because the teachers themselves had been taught by rote learning methods and we knew nothing else so we were forcing these methods onto the children.

It was not the project or the children or constructivism that was put on trial. It was the teachers. Consequently any failure could be attributed to the teachers. In this situation it is not surprising that the teachers did all they could to make this work and could not say "This is not working."

Mrs P reported that during the experimental year the teachers were "cheating" (Transcript, Mrs P:30-31). They were "stealing" (Transcript, Mrs P:30-31) time from other subjects in order to fit in the mathematics. While they complained among themselves they never let on that things weren't working as they should. Teachers who were held up as examples to give demonstration lessons had been known to take their previous year's class, which was "better" at the new approach.

7.3 Discussion

This study has indicated that the junior primary teachers involved in this curriculum innovation have limited access to the regulating principles underpinning it. The reasons for this lie with the process of curriculum innovation, with what is recontextualised from the academic practices into the official pedagogic practice and what is transmitted to the teachers in the form of official communications.

Limited access, I would argue, places constraints on the successful implementation of the innovation by teachers because it inhibits their ability to interrogate their own practice, and their ability to enlarge on their repertoire of practices. As teachers are the initiators of change in the classroom, rather than the "mediums of change" (Lerman, 1992:221) the implementation of a curriculum innovation may indeed rest on the extent to which the teachers have access to the regulating principles.

7.3.1 Reasons for limited access

The fact that teachers have limited access to the regulating principles underpinning the "new mathematics" does not indicate a deficit on the part of the teachers, but rather points to how the transmission of knowledge from academic practices, through to the teachers' practice, occurs. In order for teachers to have access to the regulating principles underpinning the curriculum innovation, a sound conceptual base, including a theory of knowledge, a theory of learning and an understanding of the mathematical principles involved, must be made explicit in the official pedagogic practice.

The Teachers' Guide supporting this curriculum innovation does not make explicit a conceptually-sound theoretical base. Whether there is indeed a sound conceptual base in academic documents supporting this innovation remains an important question. From my readings there seem to be conceptual gaps in the constructivist theory which this innovation appropriates. Von Glasersfeld (1987:16) indicates such a gap when he says that the structure of mathematical concepts to which teachers are to lead children is still largely obscure. Steffe and Wiegel (1992) also indicate a methodological gap when he states that in order for a constructivist innovation to work, a different school mathematics is required.

However, the fact that these problems exist in constructivist theory does not preclude teachers having access to it, as some aspects of the theory may inform their teaching. One of the teachers in my sample relates how excited she was at an initial meeting where the theory underlying the new approach to mathematics was introduced to teachers. The theoretical underpinnings were soon lost and it became the "RUMEUS team theory as to how mathematics should happen in the schools" (Transcript Mrs P:28), and was embodied in the documents put out by RUMEUS (Human et al., 1989) and the Teachers' Guide (CED, 1993).

By not including a sound theoretical base, but using procedurally elaborated text and prescriptive statements, the Teachers' Guide positions the junior primary teachers in a subordinate role, which is essentially alienating.

7.3.2 Consequences of limited access

It was evident in this research that teachers have in existence their own understandings of how children learn and how knowledge is transmitted. Talking about her former mathematics teaching Mrs Print says;

... then the teacher had great satisfaction because you knew they were getting regular consistent teaching, and regular consistent teaching is what makes knowledge happen. O.K. You can't have this hit and miss story (Transcript P:19).

Access to the regulating principles of the curriculum innovation might challenge the theories already in existence, in which case the former theories may undergo some transformation, or alternatively the new theories may be thrown out as not having a sound conceptual base.

Without access to the regulating principles underlying the curriculum innovation, teachers are left in a theoretical vacuum. They are told that the teaching methods they employed formerly are to be substituted by a new set which have been found to be superior by "research". Referencing research is not deemed to be necessary for the teachers.

But without the theoretical backing, the "new" procedures are not likely to be implemented, or if they are, they may fail as lacking conviction.

Because there is unconscious resistance in the mind and in the soul. And I think it is absolutely essential, it's called human rights, it is absolutely essential that teachers are confident about whatever method they use. If they are not confident about it and they don't like it they are going to do so much damage to that method. I mean they do damage in their body language, they do damage in the comments they make, and the fact is they get so depressed (Transcript Mrs P:21).

Without access to the theoretical underpinnings the teachers have two alternatives. One is to reject the new curriculum. And this will certainly happen if the procedures outlined are inconsistent with the theories already in place. The second is to incorporate superficial aspects of the new curriculum into an already established theoretical framework. In this case the new curriculum is ineffective.

Collaboration between researchers and educators who develop the theory with teachers who are the practitioners at the theoretical level, and about the realities of implementing such theories in classroom practice, is essential if the curriculum innovation is to succeed. This would apprentice teachers into the esoteric domain, and give them access to the regulating principles. Teachers in a dominant subject position, with access to the principles underlying the "new mathematics" are in a stronger position to implement the "new mathematics".

7.3.3 Initiators of change

Lerman (1992) states that teachers should be "seen as they are, the initiators of change" and should not be constructed as "mediums of change" (Lerman, 1992;226). The classrooms are the laboratories in which curriculum innovations are tested. However, casting teachers in a subordinate role by not being explicit about theoretical underpinnings does not allow teachers to participate fully in the innovation. Unless the teachers are engaged at a theoretical level there can be little communication between teacher and researcher. The constraints on the communication between academic researcher and teacher was evident in this research. The strong classification between the teacher and the "mathematics professor" precluded a common discourse. This is not an isolated phenomenon. Throne (1994) talks about the difficulty of finding common ground when communicating classroom experiences to educators (Throne, 1994:196), and Narode (1993:7) states that unless mathematicians and researchers begin to value what teachers have to offer there is very little chance of communication.

7.4 Conclusion

While academics and researchers may design and initiate new curricula, the teachers are an essential part in the implementation of the curricula. In my view teachers having access to the regulating principles, who are apprenticed into the esoteric domain and are able to generalise from a position which is context independent, are going to be in a position to implement change in their classrooms.

Given the alternative scenario, where teachers have no access to regulating principles, are alienated from the esoteric domain, and tied to localised, context specific knowledge, there is likely to be a rejection of new curriculum, or at best an appropriation of only the superficial aspects. In the latter case, the curriculum planners may go back to their desks desperate about one more failed curriculum, and start planning again for a new "new mathematics" which will fail again unless as Mrs Print suggests;

I would really just say if you can have any influence in any way - I suppose this is just a study for yourself- but if you could have any influence on people is that when they change methods so drastically that they have got to have the teachers on their side (Transcript Mrs P:37).

The question inevitably arises whether teachers themselves see the theoretical underpinnings of the "new mathematics" as important. It would be interesting to pursue Clark's idea of teachers as self-directed professionals (Clark, 1992) and see whether teachers do pursue the theoretical underpinnings of their practice. This could be the focus of another study.

A further question relates to ontological reality. My re-construction of the theoretical underpinnings of the "new mathematics" serve as the regulating principles underpinning the activity of teaching mathematics. Given the same scenario, would the regulating principles be constructed similarly by another researcher/teacher? Is it regulating principles which determine teacher activity in the Junior Primary School or is activity regulated by the caring relationship between teacher and child, and an intuitive grasp of what a particular child needs at a particular time, as was described by Throne (1994). Even if this is the case access to regulating principles would in my view strengthen the position of the teacher.

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APPENDIX A

Interview Schedule

In the interviews I plan to investigate the transition process from a "traditional teaching" approach to a "problem-centred" approach.

This investigation will cover two broad areas;

1. The relationship between subject "experts", (teacher educators, education authorities) and teachers, from the teachers' perspective.
2. The changing practice of the teacher involving teaching strategies, classroom management, the learning process, mathematical knowledge, teacher role.

[Two aspects to this - what the theory says and what the teacher adheres to.]

1. This new problem - centred learning was brought in 5 years ago. How did this happen? How did you first hear about it?
How were you introduced to the new approach?
 - a. What was your first experience of this new approach?
 - b. What information did you get?
 - c. In what form was the information, notes, workshop, lecture, discussions?
 - d. Was it your decision to try a new approach in your classroom?
 - e. Were you given much classroom support?

2. Would you say there has been **a major change in the approach** to mathematics teaching in the junior primary school.
 - a. What has been the most profound change?
 - b. What **brought about this change?**
 - c. What did teachers at your school feel about this?
 - d. Where the interests of the children a motivating force for the change?
 - e. What was the involvement of the larger mathematical community?
 - f. Was there any consultation with the teachers?

- g. What do you understand as the key principles of the approach?
- h. Why the change? What are the theoretical underpinnings of the change?

Mathematical? (Is the mathematics learnt of a better standard, eg. more understanding)

Educational? (Is the teaching process improved?) Psychological? (What about self-concept? Do the children feel better about themselves?)

- i. In your classroom you have a certain level of autonomy about what you do, but you are accountable to the children, their parents, the principal, inspectors and others.

Is there a change in relationship between teacher and parents, parents and children?

How do these different expectations affect your teaching?

- j. Is there a channel through which you can express concerns or query aspects of this new approach?

3. Given that teachers have different **teaching styles**, would you say that most teachers in your school use a similar **(general) approach** to the teaching of the "new" mathematics .

- a. What would you say are the specific characteristics of this approach?
- b. Is there a different relationship between teacher and pupil?
- c. A different relationship from pupil to pupil?
- d. Do children reflect on what they are doing? more with the new approach?
- e. Is your (mathematics) **classroom managed** differently?
- f. Is it expected with this new approach that you manage your classroom in a particular way?
- g. What is the proportion of time spent in whole class interaction? and smaller group interaction?
- h. What in your opinion works best?
- i. Is this new approach suited to the "very bright" children? What about the "slower" children?

- j. Are there differences in "ability" between boys and girls? What accounts for these differences? How do these differences affect classroom management?
 - k. How do you plan for a mathematics lesson? What have you in mind when you select activities?
 - l. Is there a difference in noise level?
4. (I imagine with a more traditional approach to classroom teaching, the fact that the whole class did well on a test would give you some indication of how much they had learnt.) What is the view of learning underlying this new approach?
- a. How do you assess now whether a child is **learning mathematics**?
 - b. Is much mathematics learned before school and outside of school?
 - c. What about mistakes in this new approach? What do you understand as the reason for mistakes in mathematics?
 - d. How do children learn mathematics?
 - e. Is there something called natural ability?
 - f. Is there much communication between children? Do you think children need to talk about mathematics in order to learn mathematics?
5. In the new approach the right atmosphere seems to be important.
- a. How much do you focus on creating a right atmosphere in the class? What to you is an atmosphere conducive to learning?
 - b. Is this "correct environment " crucial to the learning of mathematics using the new approach?
6. Has your understanding of what mathematics is changed with the teaching of the new approach?
- a. Would you describe yourself as confident with mathematics?
 - b. What have been your past experiences been with learning mathematics yourself?
 - c. To what extent does this influence your teaching of mathematics?

- d. To what extent do you think teachers' own background qualifications/ experience in mathematics makes it easier/ more difficult to make curriculum changes this new approach has brought? Can you give specific examples?
- e. When making decisions about new curriculum, would you like to be consulted?

APPENDIX B

Summary of Sample

	Mrs Print	Mrs Roberts	Mrs Huntley
Teaching experience	29 years	13 years	31 years
Standard of class	Std 1 (3rd year of schooling)	Std 1	Std 1
Status in school	Head of department	Head of department	Head of department
Year of implementing new maths	1989	1990	1993
Referred by	Principal	Principal	Subject Advisor
Qualifications	Std 10 plus 4yrs teacher training	Std 10 plus 4yrs teacher training	Std 10 plus 3 years teacher training
Type of school	Cape Education Department Project School Primary school Sub A - Std 4 approx 400 pupils	Cape Educ Dept Primary school Sub A - Std 1 approx 180 pupils	House of Representatives Primary school 1000 pupils
	Mrs Orion	Ms Khan	Mrs Joshua
Teaching Experience	29 years	22 years	15 years
Standard taught	Std 1	Sub A (1st year at school)	Sub A
Status in school	Head of Department	Teacher	Teacher
Year of implementing "new mathematics"	1993 (unofficially) 1994	1993	1993
Referred by	Principal	Principal 3	Self 4
Qualifications	Std 8 plus 3	Std 8 plus 3	Std 8 plus 3
Type of school	House of Reps Primary School Sub A - Std 5 1000 children	House of Reps Primary School (A- 5) 1000 children	H O Reps Primary School (A-5) 1000 children