Classroom Practices Associated with the New Curriculum in South Africa

By: Nicholas Molefe

Classroom Practices Associated with the New Curriculum in South Africa

Nicholas Molefe

A research report submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial fulfillment of requirements for the degree of Master of Science by coursework and research report.

Supervisor: Professor Karin Brodie

Johannesburg, October 2008

DECLARATION

I declare that this research report is my own unaided work. It is being submitted for the degree of Master of Science by coursework and research report at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university, nor has it been prepared under the aegis or with the assistance of any other body or organisation outside of the University of the Witwatersrand, Johannesburg. All help received with the preparation and/or presentation of this thesis has been clearly acknowledged on the next page.

Nicholas Molefe

Signature: _____

October, 2008

ACKNOWLEDGEMENTS

I would like to thank the following people for the part they played in this work:

- Family, for their continuous love, support, patience and encouragement throughout my entire period of study.
- My mother and all my siblings, for their undying love and the confidence they have in me.
- My supervisor, Prof. Karin Brodie, for believing in me and giving me all the necessary support and drive, including at the time when things were becoming too challenging for me. Her knowledge, inspiration, encouragement, concern, positive and constructive criticisms made my period of study easy to handle.
- The principal, the teacher and the learners of the school where I undertook this study, for allowing me to work with them. Most importantly, the time they gave from discussion of the project to the actual videoing of lessons in the classroom.
- My former colleague, for allowing me to use his existing data for this study.
- My colleague and friend, Rasheed Sanni, for his tireless efforts to keep me pinned and focused on my target through all the guidance and insightful inputs he made towards my studies.
- My two colleagues, Stephen Modau and Zaheera Jina, for being there always through the thought-provoking and valuable critiques we had about our own studies.
- My longtime friend, and also a former colleague, Vuyo Zali, for spending some days proofreading the text.
- My brother-in-law, Thabang Ketshabile, for his expertise in helping out with all the necessary technical aspects of text layout.

ABSTRACT

This study investigates the teaching practices that enhance or inhibit effective interaction in the classroom, and the study also provides an extension of an action-research study I conducted in my Honours project. In this current study, I worked with two teachers of mathematics who both taught grade 10 classes at two different schools. The two schools had varying, contextual, racial demographics. My focus was on similarities as well as differences between the two teachers in my study. This focus was done not to judge which teacher was better than the other, but rather to give an indication that there are a variety of practices that different teachers can and do use at particular times in their classrooms. Both teachers in my study had similarities as well as differences between them in the manner in which they employed particular practices in class, but looking thoroughly across the similarities showed that some of the similarities actually provided differences in the manner in which the two teachers employed the respective practices. Some of the practices that the teachers employed promoted reasoning in learners and some did not. It was from analyses of these differences and similarities that the notion of traditional teaching and reform-oriented teaching surfaced, and both teachers showed a mixture of traditional as well as reform practices in their teaching. It became evident from analysis that one of the teachers was more reform-oriented whilst the other one was more traditionally-oriented. A deeper analysis into the practices showed that both traditional and reform-oriented practices are important for teaching, depending on how the practices are interchangeably used in a lesson situation. What I found out from studying the two teachers was that the one teacher used traditional practices more in traditional ways, and used reform practices more in traditional ways. The other teacher used reform practices more in reform ways, and could also use traditional practices in reform ways.

TABLE OF CONTENTS

Page no

CHAPTER 1: INTRODUCTION 1

1.1 Introduction to my study 1

1.2 Background to the study 2

1.3 Research Question 2

1.4 Practices 4

1.5 The new curriculum 5

1.6 Communication as a tool for reform teaching 6

1.7 Structure of the Report 7

CHAPTER 2: THEORETICAL FRAMEWORK AND LITERATURE REVIEW 9

2.1 Introduction 9

2.2 Theories of Teaching and Learning 9

2.3 Mathematics as a subject 14

2.4 Teaching and Learning mathematical reasoning 15

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY 20

3.1 Research Approach 20

3.2 Subjects 20

3.3 Data Collection 22

3.3.1 Classroom videos 22

3.3.2 Interviews 23

3.4 Limitations 24

3.5 Ensuring rigour in my research 24

3.6 Analysis of data 25

3.7 Ethical considerations 26

3.7.1 Official ethics permission 26

3.7.2 Teachers, learners and parents 27

3.8 My analytic framework 28

CHAPTER 4: DATA ANAYSIS 32

4.1 Introduction 32

4.2 Description of lessons 32

4.2.1 Mr. Thekiso's lessons 33

4.2.2 Mr. Ronaldo's lessons 34

4.3 The teachers' practices 35

4.3.1 Differences between the two teachers 37

4.3.2 Similarities between the two teachers 45

4.4 Summary 55

CHAPTER 5: CONCLUSIONS AND IMPLICATIONS FOR RESEARCH 58

5.1 Summary of Findings 58

5.2 Answering my Research Questions 61

5.3 Limitations of my study 62

5.4 Implications and Recommendations 63

REFERENCES 66

APPENDICES 70

LIST OF TABLES

Table 1: Lesson times – page 35
Table 2: Summary of practices – page 36

Chapter 1: Introduction

1.1 Introduction to my study

The introduction of the new curriculum in South Africa ushered in a variety of changes in relation to the teaching and learning of mathematics. These changes made it necessary for teachers to make shifts in their teaching practices so as to make these practices resonate with ways of promoting mathematical thinking and reasoning. In this research study, I look at how two mathematics teachers employ a variety of practices in their classrooms, some of which resonate with the new curriculum and some which do not. I will describe how these practices are enhanced by the type of interactions that take place between the teacher and learners, and in some cases between learners. I will also elaborate on the impact that these practices can have in promoting/inhibiting thinking and reasoning in the teaching and learning of mathematics.

There have been various discussions and arguments raised regarding the new curriculum, particularly in relation to its planning and implementation processes. Chrisholm et al (2000) reported on how an extensive review on the implementation of curriculum 2005 was conducted to raise the need for its transformation, and argued that "the transformation agenda in South African education needs to be deepened by addressing issues which inhibit and constrain full understanding and realisation of the goals of transformation" (p.18). This report helped me to understand that practices that teachers use in their classrooms also form part of this transformation agenda, and if carefully analysed, these practices can help contribute to the achievement of the goals of transformation. This achievement can be realised if teachers become aware of and accept the impact that these practices have on the teaching and learning of mathematics, and consequently contribute positively to the transformation agenda in South Africa by employing these practices in their respective classrooms to improve learner understanding.

1.2 Background to the study

Previously, I had the opportunity for teacher development through in-service training at the University of the Witwatersrand, and realised from that training and the discussions I held with the facilitator that I needed to alter my teaching approach. This prompted me to employ practices in my classrooms that encouraged mathematical contributions from learners. I later had an opportunity to study further while doing my Honours program, also at Wits. It was through this Honours program that I did an action-research study, which explored the shifts that I had made and still could make in my teaching. What I found from this action-research study was that I employed a number of practices that are in line with the new curriculum[1] and mathematics reforms[2] more generally, for example, challenge for justification, enabling learner participation and communication, and stirring a productive argument (Molefe, 2003). In this current study, I want to further extend my understanding of practices by looking at other teachers and seeing what kinds of practices they employ in their teaching and the influence that those practices have on learners.

My action-research study was conducted in a high school, a level at which little research has been done in investigating mathematical teaching practices. Of the studies that have been conducted so far, most were done in primary schooling (Lampert, 1998; Heaton, 2000; Elbers, 2003; Hedegaard, 1990; Mousley, 2003; Ball, 1996; Ball & Bass, 2000), with only a few in high schools (Boaler, 1997; Chazan, 2000). All of these studies were conducted overseas. It is for this reason that I want to look at teacher practices in the context of our South African high schools.

1.3 Research Question

The main question guiding my study is:

[1] *New curriculum* as used in the South African context
[2] *Reforms* as used in the international context

What are the teaching practices that enhance/inhibit effective interaction in a mathematics classroom?

I will focus on the following sub-questions to help me understand the role that these practices have in the teaching of mathematics.

a) What kinds of practices do teachers employ to teach mathematics?
b) What influence do these practices have on the learners' thinking and contributions in class?

The two questions will help me to better understand the type of practices that teachers employ in their classrooms, and which of these practices resonate with visions of reform practices, improve the learners' contributions in class and help develop their levels of understanding of mathematics. These levels of understanding will be determined by the thinking and reasoning that learners display when they communicate about mathematics in class, with their teacher as well as amongst themselves.

Within the global world, reform in mathematics teaching brings with it ways and means of making mathematics not only understandable, but also enjoyable for those who are involved in its teaching and learning. This reform is concerned with the manner in which old teaching and learning strategies can be modified in ways that make mathematics teaching and learning make sense. Thinking and reasoning are two of the skills that I find to be amongst the most important that can help bring about better mathematics learning.

Curriculum reform in our country is here to stay and it makes sense to try to understand what is required of those who have to implement it in various South African classrooms. Teachers, as classroom practitioners, have had little or absolutely no say in curriculum reform in South Africa, however they are key to its enactment in classrooms. Thus, research is needed not only to help teachers to understand the curriculum, but also to be in a better position to understand their strengths and challenges in enacting the curriculum in their various classrooms. Since all teaching is primarily concerned with the type of learners that are produced as a result of that teaching, my previous research study

(Molefe, 2003) as well as the in-service training I received at Wits University helped me to understand that there are practices that teachers can use to influence learners' thinking and reasoning. Improved thinking and reasoning are attributes of a reform curriculum and research on these aspects needs to be developed further. It is for this reason that I am now looking at what other teachers are doing in their classrooms and how their practices can be used to further develop classroom practices that resonate with the new curriculum.

1.4 Practices

I use Schifter's definition of teaching practices to look at practices as being skillful, patterned regularities that occur in teachers' classrooms (Schifter, 2001). These practices involve particular approaches or methods that teachers employ in their classrooms on a regular basis and these methods follow some social patterns of bringing meaning to the teaching and learning of mathematics. The learning of mathematics can be developed by these methods of teaching if there is appropriate interaction in the classroom. Appropriate interaction should engage learners more in their learning and help them improve their thinking and reasoning skills. Learning, as Brodie (2000) describes it, is a "process of constructing meaning that occurs in social contexts through interaction with others, especially the teacher" (p.100). I will focus on the meaning that is reflected in learning and how thinking and reasoning amongst learners can be developed in classrooms.

There are authors who have distinguished between teaching practices and mathematical practices (Rand Panel, 2000; Brodie, 2002; Cobb, 2000). Teaching practices are more general and occur in all classrooms, and these are practices such as asking questions, writing on the board and so forth. On the other hand, mathematical practices are mostly confined or specific to mathematics classrooms. Practices such as explaining, generalising, justifying, and reasoning logically are some that can be associated with the teaching and learning of mathematics. Making explanations is a practice that can be found in all classrooms, but how these explanations are made can distinguish between a

mathematics classroom and one that is not a mathematics classroom. I will elaborate more on this aspect in chapter four when I do my analysis.

In describing 'classroom mathematical practices' Cobb (2000) focuses on mathematical interpretations and reasoning. He terms this notion of mathematical practices the normative or taken-as-shared mathematical content in arguments that arise in mathematics classrooms. These mathematical practices, Cobb argues, are established by a classroom community, and "can be seen to constitute the immediate, local situation of the students' development" (p.73). I will talk more to the notion of classroom community in the next chapter when I discuss literature related to my study.

1.5 The new curriculum

The new South African curriculum has brought with it changes which, it is argued, when implemented by teachers in their various classrooms will have an influence on children's learning. The new curriculum suggests making the learning of mathematics to be a thoughtful and enriching exercise or process that is characterised by, amongst others, "competently using mathematical process skills such as making conjectures, proving assertions and modeling situations" (National Curriculum Statement, 2003: 10). Learners who have gone through this new curriculum will be expected to competently apply the knowledge that they acquired in class to other situations, including real-life situations. Bernstein (1982) talks about "weakened boundaries" with regards to "the framing of the curriculum" (p.159), wherein the teacher's role becomes more of a mediator and the learner is expected to take responsibility for his/her learning. The new curriculum is therefore a framework that should guide teachers on their day-to-day activities in their classrooms. These activities include, amongst others, the type of practices that respective teachers can employ in their classrooms to promote thinking and reasoning in mathematics.

Since implementation and mastering of this new curriculum by teachers is a process, there are still teachers who find themselves accustomed to traditional methods or

practices of teaching in their classrooms. They continue to remain traditional in their approach because they find alternative methods to teaching not easy to understand or work with. Traditional teaching stressed "transmission of information achieved through teachers' 'talk and chalk', whilst children took notes and wrote exercises" (Edwards and Westgate, 1987: 9). Learners' talk was mostly confined to chorusing or reciting their answers by rote, and these answers being short. Some authors have referred to similar practices as IRE/F (Initiate-Respond-Evaluate/Feedback) approaches in teaching (Brodie, 2004; Mehan, 1979), where the teacher asks a question, the learner gives a response, and the teacher evaluates the response or gives his/her feedback and the next cycle continues with an initiation by the teacher. The children's answering of questions mainly tested memory and attentiveness rather than the promotion of thinking and sense-making. The new curriculum suggests that teachers create opportunities for learners to express themselves mathematically and improve their thinking and reasoning through constructive and sustained arguments in their mathematics classrooms.

My study focuses primarily on new curriculum practices, but I will not necessarily bracket out the good that traditional teaching can still do in the new curriculum approaches, lest I "throw the baby out with the bath water". Considering good traditional approaches in teaching can assist with practices that teachers can still employ to develop thinking and reasoning amongst learners.

1.6 Communication as a tool for reform teaching

Edwards and Westgate (1987) argue that meaningful talk provides a process whereby communication of ideas in the classroom will create conducive atmospheres for learners to engage one another as well as to engage their teacher in constructive discussions. Meaningful talk in a classroom can be enabled by practices that engage learners in meaningful discussions and promote thinking and reasoning. It is this talk that is lacking in many of the South African mathematics classrooms that I have observed thus far. I will look at the practices that I have observed in two mathematics classrooms in South

Africa and how these can be developed to improve practices in other teachers' mathematics classrooms.

As we listen and as we talk, we learn about the necessary practices that should be employed in that area of social life or that setting (Edwards and Westgate, 1987). Understanding practices in a particular setting, Edwards and Westgate argue, will display the competency that is necessary for one to be accepted as a member in that area of social life. Being conversant with employing practices that promote thinking and reasoning depends on how a teacher negotiates his/her talk in class, how s/he asks questions, how s/he evaluates the answers as well as how s/he generally manages the teaching and learning process in the classroom. I will seek to better understand the range of classroom practices that teachers employ in their teaching to enable/inhibit meaningful interactions in their classes, and if these practices do/do not help learners to make sense of mathematics.

1.7 Structure of the Report

In Chapter 2, I describe the two theories that influence my research study. I will explain why I use these theories and draw on literature to help me understand why these theories are important for my study. I will present the literature that I draw on to make links to two aspects that are involved in mathematics, namely mathematics as a subject and the teaching and learning of mathematics.

Chapter 3 focuses on my research design. In this chapter I focus on the methodology that informs my research. I will explain why I use this methodology and describe the methods that I have used to collect my data. Justification of the use of these data collection methods will also be provided. Since my research focus is primarily on the practices that teachers employ in their mathematics classrooms, I will also provide detailed description of categories that I developed to analyse teachers' practices. This chapter also deals with measures I took to ensure, amongst others, the reliability and validity of the results of my study.

In Chapter 4, I use the categories that I develop in chapter three to analyse in detail the kinds of practices that the two teachers employ to teach mathematics. This chapter provides the analysis that will answer my research questions. My analysis will also refer to my conceptual theories and the related literature that I describe in chapter two to help me make links with the categories I use for my analysis. Since two teachers are involved in my study, I will look at the similarities as well as the differences between the two teachers, and illuminate the strengths and weaknesses in their practices.

Chapter 5 will be my concluding chapter, wherein I will give an overview of what I have found in the study with the aim of answering my research questions. I will also look at how my research study helped me to understand teaching practices that are employed in mathematics and how these can be used to assist other teachers to better understand what can help them to implement the new curriculum. A discussion of the implications that teachers' practices have for the profession and the research community will also be given. I will also make my recommendations and suggest methods by which the practices that I have analysed in this research study can be disseminated to other teachers.

Chapter 2: Theoretical Framework and Literature Review

2.1 Introduction

This chapter deals with theories that I use to help me understand how teaching practices impact on the teaching and learning of mathematics. I also draw on literature that will help me develop categories that I will use in analysing practices that the teachers in my study employed in their mathematics classrooms.

2.2 Theories of Teaching and Learning

This research study is influenced by two theories that have been used in a number of research projects. Since my exploration is on classroom practices employed in the teaching of mathematics, I locate my study within a socio-cultural perspective (Vygotsky, 1978). Practices come up as a result of interactions that take place in the classroom and a classroom is a social setting for learning, so Vygotsky's theory is appropriate. In addition, viewing a mathematics classroom as comprising a community of social practice (Lave, 1996) makes me locate this research within a situated perspective (Lave & Wenger, 1991).

Vygotsky's notion of the zone of proximal development (ZPD) provides me with a resource to understand how interactions that occur between the teacher and the learners, as well as amongst learners themselves, influence the teaching and learning of mathematics. Vygotsky defines the ZPD as

> "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with capable peers". (p.86)

Teacher practices and learner contributions can play a role in creating and working with the ZPD of each learner. Learning is a "process that involves interaction" (Brodie, 2000), negotiation of meaning and exchange of ideas. The interactions that take place between the teacher and the learners, as well as among the learners, do so in a social space that exists between them. I will describe these interactions in the context of practices that teachers employ in their teaching of mathematics and explain how some of these practices influence learners' contributions and learning in class. In my previous project (Molefe, 2003) I showed that some of the practices that I used in class were observed and appropriated by learners, and learners eventually used those practices in the development of their learning. An example was challenging learners to give meaningful explanations. Learners took this practice up and later challenged me to make meaningful explanations. In this project I also looked to see whether learners took up teachers' practices. For a particular aspect of teaching and learning to be viewed as a practice, I will want see if that aspect of teaching and learning follow some social pattern of bringing meaning in the teaching and learning of mathematics. A socio-cultural theory of learning therefore informs analyses of how individuals participate in social practices.

With the new curriculum, teachers of mathematics find themselves in positions of having to change their teaching. However, teachers are not to be viewed as the only people who can make a positive contribution towards learner understanding of mathematics. Learners, by virtue of being in a mathematics classroom, are participants in as far as thinking and reasoning are concerned. Learners are also capable of making valuable contributions by making their ideas or thoughts known to other members in the classroom, or by asking questions that are thought-provoking. They can also help other learners as well as the teacher in informing further learning and teaching of mathematics. Learners, as coparticipants (Lave & Wenger, 1991), do have a vital role to play in their learning of mathematics, as individuals as well as in groups. As individuals, learners can learn from the teacher as well as from other learners, and this learning can be explained by Vygotsky's (1978) notion of the zone of proximal development. How well this learning process is negotiated and managed depends on how well the teacher mediates whatever content he/she deals with in the classroom with his/her learners at any particular

time of his/her teaching. I will elaborate more on this in the subsequent paragraphs as well as in the subsequent chapters.

Social practices that I investigate deal with how teachers can create, in a classroom, environments that can promote or inhibit learners' thinking and reasoning. These environments can be created through a variety of practices, as is the case with getting learners to explain themselves, and making follow ups on learners' explanations. How teachers handle learner responses is an important factor in the teaching and learning of mathematics and contributes to developing learners' thinking and reasoning (Brodie, 2005).

Because I also looked at the type of social engagement that can provide relevant contexts for learning and teaching (Lave & Wenger, 1991), the notion of Legitimate Peripheral Participation (LPP) played a major role in helping me to understand how practices that teachers employ can promote or inhibit thinking. In the context of teaching and learning, LPP would refer to learners as occupying a legitimate position on the periphery, a position from which they learn from the expert, their teacher (Lave & Wenger, 1991; Lave, 1996). However, being on the periphery still provides them with opportunities to make contributions, despite the fact that they are still learning the necessary skills that will one day help them to become experts themselves. It is from this peripheral position that learners learn practices such as justification and generalisation, as well as challenging other members in their classroom community to practise those by influencing their thinking.

To influence a learner's thinking can help him/her to reflect on his/her contribution and provides room for him/her to justify the contribution that he/she made, or change his/her mind if the need arises. "Changing one's mind is not only a matter of rational decision making, but is a social process with social consequences" (Lemke, 2001: 301). Increased participation of learners in class can be encouraged if learners get to a stage where they realise and understand that their thinking at times can have some flaws and will need to change in ways that will make it resonate with what other members in class say or

discuss. It is not simply about what is right or what is wrong in the narrow sense, but rather knowing why you are correct/not correct (Lemke, 2001) and developing your powers of reasoning about your own and others' contributions. I will elaborate more on the flaws that go with learners' thinking in one of the subsequent sections.

Lave & Wenger (1991: 36) argue that "peripherality is an empowering position" as one moves toward more intensive participation. Learners as apprentices in learning (Lave, 1996) can gain access to sources of understanding through growing involvement (Lave & Wenger, 1991) in the interactions that occur in the classroom. These interactions also include the teacher's contributions as the expert (Lave, 1996; Brown et al, 1989; Wood, 1995) in the process of sharing his/her knowledge and use of practices with learners as legitimate peripheral participants. I find the theoretical perspective of situated learning to have some similarities with socio-cultural perspective, as they both provide ways of understanding how learners can learn from the teacher as well as from each other. The focus that situated learning and socio-cultural perspective take in relating learning to the social situations in which learning occurs, helps in identifying practices that are acquired through the learning process, and how these practices are developed further.

I am using two theories to guide my research as they both inform us about the learner and learning from a social perspective and a learner taking ownership of that which he/she learns to further his/her learning or development. Both theories are dialectical as they emphasise the interaction between the individual and the social, and the two theories also consider learning as a social process. The unit of analysis in a socio-cultural perspective is the interactive dyad, consisting of two 'minds' in interaction (Brodie, 2005). The one mind in this context is that of the teacher, and the other one is of the learner. Vygotsky (1987) argues that learning takes place in two planes, on the inter-psychological as well as on the intra-psychological, where the inter-psychological refers to the interaction between people and the intra-psychological is when this interaction is internalised as learning. What is therefore internal in "higher mental functions" (p.80) was at some stage external, between people. Teaching in the ZPD can provide that transitional process between the inter-psychological and the intra-psychological planes. Vygotsky (1987)

says that the ZPD "defines those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state" (p.86). He terms these functions the 'bud' or 'flowers' of development instead of the 'fruits' of development. The inter-psychological therefore relates to the 'buds' of development whilst the intra-psychological relates to the 'fruit' of development. Internalisation of practices by learners is therefore an indication of mental functions going through a process of maturation.

On the other hand, situated perspectives look at the group as a unit of analysis. What this means is that if a person finds him/herself in a group, then the group is in a better position to regulate him/her, especially if there are knowledgeable people in the group. The situated perspective argues for social factors being the ones that constitute learning, and do not only enhance or inhibit learning (Brodie, 2005). Hanks (1991) situates learning in particular forms of social "coparticipation as opposed to locating learning in the heads of individuals" (p.13). Learning is therefore distributed amongst participants and is not necessarily a one-person act. Learning can be viewed as participation, rather than caused by participation. As learners participate in class, the interactions that take place between them and their teacher as well as amongst themselves indicate what kinds of learning are taking place.

In this section, I have described how the two theories of socio-cultural and situated perspectives can help me understand teachers' practices in improving learners' thinking and reasoning. In the next section I discuss two additional issues that relate to researching teachers' practices.

- Mathematics as a subject, and
- Teaching and Learning mathematics.

2.3 Mathematics as a subject

Mathematics, like any other subject, needs to make sense when it is being taught or learned. It is my assumption that when learners' thinking and talking in mathematics is supported, their mathematical reasoning will be developed. The support that can be provided for learners is through practices that teachers employ in handling learner responses as well as how learners' contributions are encouraged in the teaching and learning of mathematical reasoning. By mathematical reasoning I mean establishing some truth about a particular aspect of mathematics, finding some evidence or justification for the truth that one has assumed, and knowing why you are correct or incorrect (Open University Press: 1998). Thinking and reasoning mathematically is one of the attributes of being proficient in mathematics.

Kilpatrick et al (2001) discuss five strands of mathematical proficiency. Four of these strands are conceptual understanding, procedural fluency, strategic competence and productive disposition. The fifth strand of adaptive reasoning is the one that informs my research the most. I focus on their notion of adaptive reasoning which, they argue, holds the other four strands together. They argue that adaptive reasoning refers to the capacity to think logically, and includes knowledge of how to justify conclusions.

In relation to the discipline of mathematics, Brodie & Long (2004) argue that attention be given to "the content of mathematics; the process of mathematical thinking; and what counts as doing and thinking mathematics" (p.6). This suggests that mathematics is not only about knowledge of numbers, symbols and procedures; it is also a subject that involves justifying, communicating, thinking and reasoning. Encouraging these practices in a mathematics classroom can provide opportunities for learner development. When attention is given to the content, processes and practices of mathematics, learners will be in a better position to use their knowledge in future interactions.

Teaching mathematics involves enabling learners to make sense of mathematics in ways that help them not to depend entirely on their teacher, but to also rely on their problem-

solving skills, and their thinking and reasoning. It is important that learners know and understand that "answers are right because they make sense and follow a particular line of reasoning that is valid" (Kilpatrick et al, 2001:129), rather than merely accepting what the teacher and textbook tell them.

The next section looks at studies that investigate the impact that practices make in the teaching and learning of mathematics. Working in the ZPD of learners and empowering them from their peripheral position through practices that teachers employ in their classrooms can help develop the learners' thinking and reasoning abilities.

2.4 Teaching and Learning mathematical reasoning

In this section I review a number of studies on classroom practices as well as teaching and learning mathematical reasoning. These studies help me to understand various practices that teachers employ in their teaching and how these practices impact on the learning of mathematics. I will use the studies to help me develop categories in Chapter 3 that I will use to analyse the teachers' practices and how these practices promote or inhibit mathematical thinking and reasoning.

Elbers (2003) observed Streefland in practice and was intrigued by his approach of teaching children. Elbers explains that Streefland used an inquiry-based approach and addressed the children in his class as researchers. Elbers argues that creating a learning community in which learners produce and discuss ideas allows for their mathematical creativity to blossom. In this way, learners do not only benefit from their teacher, but from each other's ideas and productions as well. This resonates with the socio-cultural perspective's argument on "collaboration among children in the process of being taught" (Davydov, 1995: 16). A supporting notion is that of Lave & Wenger when describing learning as being "a way of being in the social world, not a way of coming to know about it" (Lave & Wenger, 1991: 24). These notions emphasise the importance of learners in fully involving themselves in their learning through active, participatory roles. Elbers bases his argument on the ideas of transforming classrooms into learning communities,

wherein teachers help learners to participate in the process of knowledge construction. I have discussed earlier in this chapter that learners are capable of making valuable contributions in class by making their ideas or thoughts known to other members in the classroom by virtue of being viewed as coparticipants in their learning of mathematics (Lave & Wenger, 1991). Some of my categories will describe how the classroom forms a learning community in which teachers and learners communicate about mathematics. For example, 'getting learners to explain their reasoning', and 'redirecting input from one learner to other learners' creates opportunities for meaningful discussions to take place in the classroom.

Elbers' notion of introducing meaningful problems to learners helps in making it possible for learners to learn not only the content of mathematics, but also learn the practices of mathematics such as formulating their own questions, answering them, producing mathematical arguments and validating their assertions. It is in this way that learners will benefit from participating in social interaction and collective knowledge building activities, and they will know that having a good answer or the right solution is not sufficient. They learn that they also have to be convincing. My categories include pushing learners to justify their answers. Pushing learners for justification helps them to understand which explanations are acceptable in a mathematics classroom and which are not (Kilpatrick et al, 2001).

Brodie (2005) uses Lampert's (1998) notion of a thinking practice to argue: "teaching is a thinking practice in which teachers, through their intellectual work, focus on fostering thinking practices among their students" (p.29). The classroom practices that teachers employ in their teaching can become practices that learners might also use in their learning. Learners come into the classroom bringing with them social differences that will interact with their learning environment. As they enter the classroom, they are confronted with practices that the teacher employs in his/her teaching (Hedegaard, 1990). The interactions that emanate from this environment can help individual learners to carefully observe how the teacher goes about engaging other learners in his/her lessons with the use of practices that promote mathematical reasoning. How the teacher engages

learners in class will help them know how they can engage one another, when an input from one learner is redirected to other learners. As mentioned above, redirecting inputs is a category in my analysis.

When learners enter the classroom, the teacher confronts them with zones of proximal development through activities and interactions that will keep them engaged in the lesson (Hedegaard, 1990). It is this confrontation that can help learners acquire the necessary skills in mastering the practices as mediated by the teacher. Learners can learn from the teacher in ways that will move their understanding enough to "set up a zone of proximal development wherein meaning is negotiated to seek common ground of comprehension and understanding" (Newman, Griffin and Cole, 1989 in Mousley, 2003: 338) and progress. Different teachers use different approaches to confront learners – tasks, questions, etc. The kind of tasks assigned to learners or the kind of questions posed to learners determine the extent to which learners are engaged in a lesson. Kazemi & Stipek (2001) use the notion of high press and low press to distinguish between approaches that teachers can use to push learners into verifying their answers and approaches that do not. They argue that "high press questions encourage learners to include mathematical arguments in their explanations, whilst low press questions encourage procedural descriptions only" (p.78). These high press questions can create opportunities for learners to work cooperatively or in collaboration with each other, as they will be forced to share their thinking in preparation of convincing either the teacher or their fellow learners. The category of "pushing learners to justify themselves" is informed by this literature. In pushing learners to justify themselves, teachers can make a practice of posing these high press questions to learners so as to develop the learners' reasoning skills.

Brown et al (1989) argue that students who are taught individually rather than collaboratively can fail to develop skills needed for collaborative work. The process of teaching and learning mathematical reasoning therefore involves "thinking about what the other person has in mind and adjusting the interactions accordingly" (Newman, Griffin and Cole, 1989 in Mousley, 2003: 338). Getting different views from learners as

in redirecting their inputs and pushing them to justify their answers can help them realise what they should perceive as factual and what they shouldn't. It is common knowledge that involvement of learners in the lesson will carry with it mistakes embedded in learners' thinking, which some researchers refer to as errors or misconceptions (Nesher, 1987; Brodie, 2005). Getting learners to explain themselves creates opportunities for discussions of the errors and misconceptions that they produce. What is important is how teachers handle situations in which learners produce such errors or misconceptions. When viewed from the perspective that they inform teaching and learning, errors and misconceptions can be accepted as part of the teaching and learning process (Nesher, 1987; Brodie, 2005; Kazemi & Stipek, 2001). Errors and misconceptions are signs that learners are involved in their learning, and their thinking processes are engaged. Being accepted as part of the teaching and learning process means then that errors and misconceptions need not be discarded, but further explanations can be encouraged from learners to understand why they made those errors and misconceptions. In discussing these errors and misconceptions, further thinking and reasoning can be provoked and learners can develop practices of making meaningful contributions in future. Informed by this literature, I use 'getting learners to explain themselves' as one of my analytic categories.

The studies by Elbers, Lampert and Hedegaard are all located within primary schools, and situated overseas. I investigated teaching practices in high school classrooms in South Africa. My current study is encouraged by my study of my own classroom (Molefe, 2003) which showed that learners can reflect thinking and reasoning skills when these are encouraged by the teacher. In this study I wanted to investigate the practices of two other South African high school mathematics teachers to see the extent to which they promote or inhibit mathematical reasoning.

Due to the "malpractices" of the past in relation to the traditional methods of teaching, many teachers could have gone through a system of education that did not provide them with conditions to express themselves fruitfully as learners. Some international studies have also shown how traditional curricula impacted negatively on the classroom

(Cornbleth, 1990; Boaler, 1998; Stein et al, 1996). Kazemi & Stipek (2001) make an appeal that the current cohort of teachers creates such conditions of learning for their learners to engage in practices that resonate with reform approaches. This is a challenge that current teachers have to deal with. In an attempt to address these challenges, I hoped to come up with findings through my research project, which can be used to develop myself, other teachers of mathematics, as well as the profession in general.

Drawing on the above, my study identifies a set of classroom practices of two teachers and shows how these influence the mathematical reasoning of their learners. My next chapter deals with my research design and methodology. I will discuss my data collection strategies as well as the necessary processes I employed to prepare my analysis of the data.

Chapter 3: Research Design and Methodology

3.1 Research Approach

My research approach takes the form of a qualitative case study. My interest was in exploring teacher practices in the ongoing flow of mathematics lessons, as well as the contributions that learners make to their learning. To help me achieve my objective of an extensive study on classroom interactions, I found a case study approach to be most relevant to my research problem (Verma & Mallick, 1999; Opie, 2004). I decided to work with two cases so that I could look across two different classroom environments and thus provide an analysis that is not only based on a single source. Being able to compare practices across two teachers strengthens my findings as I can point to similarities and differences between them.

3.2 Subjects

My research questions required of me to focus on teachers who teach in a particular way, i.e. teachers who employ practices that encourage interaction in the classroom. The one challenge that I faced was finding such teachers. I had a few names in mind of teachers I wanted to approach and work with, and who I thought would encourage interaction. I approached six teachers and explained to each of them that I'm interested in learning more about the kinds of practices that teachers employ in their classrooms to encourage interaction, and to what extent do those practices promote mathematical reasoning. I also explained how long I intended to be in their classes to observe their teaching, and I discussed with them all the necessary logistics that deal with ethical research. I made these explanations to the teachers to help them understand what my research was all about, and how I would like them to be involved in the study.

From these conversations, I made a decision on the two teachers who I wanted to work with as subjects of my study. I encountered difficulties with one of the two teachers that

I had selected because the timing of my data collection coincided with the preliminary examinations for grade 12 learners, and the teacher was involved in the process of running the examination[3]. In discussions with my supervisor, we agreed that I use existing data from one of her previous subjects that would fit the description of teachers I wanted to work with. For ethical reasons, I have used pseudonyms for the two teachers in my study. I will refer to the one teacher as Mr. Ronaldo, and the other one as Mr. Thekiso. Mr. Ronaldo had a B.Sc. Honours degree which included courses relating to the new curriculum, whilst Mr. Thekiso had a post-graduate diploma in education (Further Diploma in Education) which did not focus at all on the new curriculum Mr. Thekiso did however get training on the new curriculum offered by the Gauteng Department of Education. The training by the Department of Education was offered in one week of the school holidays, a year before the implementation of the new curriculum in grade 10. Both of the teachers were observed teaching Grade 10. There were 42 learners in Mr. Ronaldo's class, and 34 in Mr. Thekiso's class.

The two teachers worked in schools that were not well resourced. None of the two classrooms had an overhead projector. The only equipment present in each of the two classrooms was a chalkboard, learners' desks, with Mr. Thekiso's classrooms having a teacher's table and chair and none in Mr. Ronaldo's classroom. In Mr. Ronaldo's school, the teacher remained in his classroom and learners moved from one classroom to the other, depending on the subject/learning area they were supposed to attend. In Mr. Thekiso's school, it was the teacher who had to move from one classroom to the other to attend to his classes. Mr. Thekiso's school is in a black township, Soweto, with only black African learners. Mr. Ronaldo's is in a formerly "Coloured" area with African, "Coloured", and Indian learners.

[3] This happened because I did not get permission from the Gauteng Department of Education to conduct the research for more than three months.

3.3 Data Collection

To ensure that I obtained useful data for my analysis, I worked with a colleague of mine whose role was to operate the video camera in class, and I took notes as an additional measure. Even though I only collected data from one teacher, I interviewed both teachers after I had observed or watched all their lessons. I used interviews not as a measure to obtain substantially new information but to confirm or engage with specific events I observed during classroom teaching (Christiansen, 2007). I developed transcripts of data from both the classroom videos as well as the interviews to use for my analysis.

3.3.1 Classroom videos

I discussed with Mr. Thekiso, whose class I visited, how I planned to conduct my research study. I fully explained my position as a researcher, and that I will not take any part in the lesson with respect to asking or answering questions, or making any contributions during the course of the lesson. This was for purposes of doing nothing that could be perceived to have influenced the outcome of my research study during the data-gathering process. I observed, and recorded a total of five lessons in five days in Mr. Thekiso's classroom. One of my colleagues helped me to record two lessons whilst I took notes, and I recorded the other three lessons. In Mr. Ronaldo's case, I watched a total of four lessons that had been previously videotaped. I observed how the teachers employed practices in their lessons, how learners contributed in the lessons and how learners' thinking and reasoning were developed through interactions enhanced by the teacher's practices. All the video lessons helped me capture the necessary practices that teachers employed in their classrooms in order to mediate between content and their learners.

The teachers involved in my study could have altered their teaching to make it suit the research, and this might adversely affect the validity of my findings. The presence of a camera and a 'stranger' in the classroom, which might be something that learners usually do not experience in their classroom could have also encouraged them to try to impress,

or became reserved and not make the usual contributions that they normally would in my absence. This was one of the envisaged limitations of my study. However, as learners got used to the video camera, they became more relaxed.

My colleague and I were trained to use the video camera by a doctoral student and we practiced filming in a colleague's school before we collected data. This ensured that we would not be limited by practical issues during the data collection and that we could focus on capturing the classroom practices.

3.3.2 Interviews

I conducted interviews with each of the two teachers. The purpose of the interviews was to obtain another source of data to provide for more robust analysis. I conducted the interviews after watching all the lessons for the two teachers. I took about 30 minutes with each teacher for the interview. The interviews focused on what transpired in the lessons that I observed with respect to teacher practices and learner contributions.

The interviews I conducted were semi-structured and helped me understand what teachers think about mathematics, how they teach it, why they teach in that way, and how they mediate their teaching with their learners to encourage thinking and reasoning. A semi-structured interview also allowed me to decide about what to follow up on, and what to probe (Opie, 2004; Frankel & Wallen, 1990). I put the teachers at ease by informing them that I was not looking for right or wrong answers, but rather interested in their views about the teaching of mathematics. I have attached my interview schedule in the appendices.

I piloted my interview with a teacher who was not in the study and visited the teacher for a day to observe her teaching and interview her about her teaching approaches. This helped me to refine my interview questions and to understand the extent to which the interviews would help my data analysis. An interview represents an interaction between the interviewer, the interviewee and the context of the interview (Bassey, 1999). Context

informs on the relevance of the interview as well as helping the interviewer to be considerate on matters that can make or break the success of the interview. My role as a researcher was a demanding one in asking the questions, recording answers and trying to keep the interview interesting, worthwhile and non-threatening to the interviewee.

3.4 Limitations

Various authors have pointed out that information obtained through a case study cannot be generalised (Verma & Mallick, 1999), and there is a danger of findings being distorted as a result of unrecognised biases in the researcher. Since I focused on only two classrooms in my study, it is very difficult to make general claims. However, seeing the similarities and differences between the two teachers, and since this project complements what I have done before in my Honours research study, this has put me in a better position to work in a more rigorous and systematic manner, and make informed conclusions in as far as my findings are concerned.

I have already explained limitations with regard to the conduct of teachers and learners when research is conducted in their classrooms. The next section deals with ensuring rigour in my research, and I will speak to issues relating to reliability, validity and trustworthiness of my research study.

3.5 Ensuring rigour in my research

The challenges and limitations that I have mentioned in the previous sections put me in a position of striving for rigour in my research and making it trustworthy. Trustworthiness in my research was backed by "getting the descriptions right and making them count" (Adler & Lerman, 2003: 441). These descriptions relate to focusing my research study within the "reform initiatives that are being researched and developed, seeing to it that the design, instrumentation, data collection, interpretations, and claims made are rigorous and valid" (Adler & Lerman, 2003: 444). In order to develop a rigorous and valid study,

I sought to employ a research approach that was relevant to my research questions. The data that I collected through lesson observations, the interview questions that I asked, and the categories that I developed for my analytic framework and how I made use of these categories helped in making my research have shape in as far as validity and reliability are concerned.

By validity I mean the extent to which a research finding is what it is claimed to be (Bassey, 1999), and whether the research tools that I planned to use (interview and observation) actually captured what they were supposed to capture (Wellington, 2000 in Opie, 2004: 68). Being a qualitative researcher means that I was availing myself as a 'research instrument' in collecting data that will help make my study to have meaning with respect to my research questions. The experience I have from my previous study, my knowledge of and sensitivity to classrooms, the analytic framework I developed from the literature as well as from my experience, all help to improve the validity of my study.

Reliability refers to the extent to which similar results can be produced under "constant conditions on all occasions" (Bell, 1999 in Opie, 2004). I have earlier mentioned that I wished to complement what I had previously explored in my Honours research. This provided three settings which add to the reliability of my findings. The three different settings of my research provided three different sets of subjects that I worked with and three sets of practices to think about.

3.6 Analysis of data

I began my analysis immediately after obtaining all my data. My analysis is based on classroom observations that I made and post-lesson interviews. This analysis was backed up by notes that I took during lesson observations. My research framework is informed by an approach that works inductively in analysing data (Hatch, 2002). An inductive approach requires that one develops categories after reading through the data. I watched each of the lessons repeatedly in order to get common practices across the lessons that

provided me with enough information to develop categories. It is from these categories that I give an in-depth analysis of my data in chapter 4. These categories are both informed by the literature in Chapter 2 of this research study and are grounded in the data.

To further improve the degree of trustworthiness in my research, the following strategies were employed:

- We had a number of sessions with my colleagues (a Doctoral student and two Masters students) that were organised by our supervisor, where we presented our findings from our respective analysis to each other and critiqued each other and ourselves.
- We also made presentations with my colleagues mentioned above to first year Masters students. Their questions and critiques also pushed some of my ideas further.
- Triangulation ((Merriam, 1992; Opie, 2004; Bassey, 1999), by bringing in data from three settings as explained above.

3.7 Ethical considerations

3.7.1 Official ethics permission

I received approval from the School of Education Ethics Committee of the University of the Witwatersrand (Protocol number: 2006ECE07), as well as permission from the Gauteng Department of Education to do research in a GDE school. This is the minimum procedural requirement for ethical research. Below, I explain how I conducted myself ethically in relation to my subjects.

3.7.2 Teachers, learners and parents

Since teachers and learners played a major role in my research project, as subjects of my study, I believe that as a researcher, I have particular obligations towards them. The most important obligation being that they should be protected from any malpractices, information distortions, biases, or whichever practices that may infringe on their rights as participants in my study, or as human beings. I was influenced by Verma & Mallick's approach (1999) of foregrounding Ethical Guidelines by The British Educational Research Association (BERA, 1992) in outlining the responsibility of participants. One of the issues they outline is

> "Participants in a research study have the right to be informed about the aims, purposes and likely publication of findings involved in the research and of potential consequences for participants, and to give their informed consent before participating in research". (p.147)

This helped me in making an arrangement to meet with the prospective teachers for my research and explain to them my interest in their teaching and why I wanted to observe them in practice and use a video camera. Official letters to the particular teachers and their principals were written to ask them for permission to conduct my research in their respective schools.

My hope was for all learners and parents to agree to my requests, which they did, except for one learner who chose not to be captured on camera. I had explained to the teacher and the learners about respecting their views and decisions. The learner who did not wish to be videotaped, nevertheless participated in the normal way in class, but I made sure that I did not capture him on camera. Capturing the learner on camera by mistake would have meant that I would not include him in any discussions with the teacher, nor include any of his input in my transcripts, analysis or any future research related activities. In the case of the previously collected data, permission was also obtained from all except one learner who was not captured on video.

There is a high possibility for the existence of power relations between me as the researcher and the teachers that I observed, or between me as 'some stranger' in their classroom and the learners. Being aware that collection of data was for research, the teachers could have adjusted their teaching to suit the research study, and they could have experienced some discomfort in the process which may have positively or negatively affected my data and their teaching. These are issues that I consider in my analysis and my last chapter.

I owe it to the subjects in my study as fellow human beings, to interact in ways that I would expect and appreciate if I was in their shoes. I have been a subject of a research study myself in the past and therefore appreciate the respect that these ethical procedures require and promote. This sensitivity helped me, I believe, to get the maximum cooperation from the subjects in my study, and this helped me to get data that is valid and reliable.

3.8 My analytic framework

My analytic framework was informed by literature as well as categories I used in my Honours study, wherein I worked with a range of categories that described how I developed the teaching and learning of mathematical reasoning. I did not use an existing framework for this research study. Rather, I generated my own framework by working through my data set and developed main categories and sub-categories from patterns I saw in my data. I then used these categories to analyse practices that the two teachers employed in their classrooms.

Below I give a set of categories I developed after watching all the lessons and listening to the interviews. I have provided a description of each category that I have used and why I used it, as well as how it links to the literature in Chapter 2. I initially developed a long list of categories and compared them to see which of them link to one another. There were overlaps between some of the categories, hence the formation of the main categories as well as their respective sub-categories. The main categories are:

- Providing meaning
- Integrating topics of the lesson
- Checking learner understanding
- Raising/maintaining interest
- Pushing learners to justify

In what follows I discuss each category and its sub-categories, and make links with the literature.

Providing meaning: This category helped me to look at patterns in the lesson that I took to be making the lesson more meaningful to learners.

Sub-categories were: inserting mathematical language/terminology; writing on the board; raising the task level and using prior knowledge to engage learners.

Providing meaning puts learners in a better position to use whichever knowledge they gain in a particular lesson in other topics and to solve new and unfamiliar problems, thus providing evidence of movement within their ZPD (Vygotsky, 1978). Movement within the learners' ZPD will be evident when learners start producing mathematical arguments and validating their assertions (Elbers, 2003; Cobb, 2000).

Integrating topics of the lesson: This happened when the teacher did not only focus on the topic at hand, but also linked the subject matter to other topics of mathematics or topics in other subjects or learning areas. Integrating topics in a mathematics lesson can help learners "observe the connection and the differences in how ideas are used in different contexts" (Lampert, 2001: 260). I do not have sub-categories for this main category of 'Integrating topics of the lesson'.

Checking learner understanding: The teacher checked if learners followed the flow of discussion in class. In checking for learner understanding, a teacher would put an idea in the public realm for learners to engage with it. This idea could emanate from a question

posed by the teacher or a response obtained from one of the learners in class (Heaton, 2000; Lampert, 2001).

Sub-categories were: asking learners to come to the board and demonstrate or give explanations; asking a learner to repeat/re-explain what someone said in class; redirecting input from a learner to other learners (Lampert, 1998; Heaton, 2000); recapping/summing up a section of work or the whole lesson; and giving classwork. These sub-categories bring up the concept of learning as being a process of coparticipation (Hanks, 1991), wherein all participants are given equal status in as far as their contributions is concerned. Learners are also developed to make some strides from their peripheral position and come closer to becoming more knowledgeable (Lave & Wenger, 1991; Lave, 1996) within the field of mathematics.

Raising/maintaining interest: this was done to engage learners in the lesson and encourage them to make contributions throughout. When Streefland addressed learners as researchers, the idea was to encourage them to have interest in what they were doing in class (Elbers, 2003). This interest can also be raised if the lesson is linked to real-life contexts (National Curriculum Statement, 2003; Schifter, 2001)

Sub-categories were: using a variety of analogies/real life context to link the lesson; working at a moderate pace and tone of voice; grasping learners' attention by simplifying input/question; and giving advice to learners to develop their interest and reasoning.

Pushing learners to justify: I looked at two ways in which justification can be obtained from learners. First, when the teacher developed a habit in learners to evaluate themselves instead of relying entirely on him. Second, the manner in which the teachers handled correct and incorrect responses from learners also helped in improving their thinking skills. It is these skills that they can use to justify their answers (Kilpatrick et al, 2001).

This chapter has dealt with all the necessary planning I needed to make my research study successful. I have outlined a number of categories in the above discussion and I will use these categories in the next chapter to give an in-depth analysis of practices with respect to similarities and differences between the two teachers.

Chapter 4: Data Analysis

4.1 Introduction

This chapter analyses the practices that the two teachers used in their respective classrooms and investigates whether these practices developed mathematical reasoning in their learners. I will analyse my data using the practices that I described in Chapter 3, focusing on how the two teachers in my study employed these practices in their respective classrooms, and the influence that these practices had on learners' mathematical reasoning.

The argument that I'm making here is that the two teachers used a variety of practices in their respective classrooms. Some of the practices that they used may promote thinking and reasoning in learners, while others may not. My interest is more on those practices that promote thinking and reasoning as they can help in developing teachers as well as assisting learners to make sense of mathematics. The development of these practices depends on, amongst others, the manner in which the teacher handles learners' responses. It is these kinds of practices, I argue, that the teaching profession and the research community can learn from in further contributing to the improvement of thinking and reasoning in the teaching and learning of mathematics. Since I am working with two teachers, I will begin by giving a description of each teacher's lessons and later explain the similarities as well as the differences between the two teachers, using the categories of practices described in Chapter 3.

4.2 Description of lessons

The two teachers in this study were both teaching grade 10 at the time of data collection. Pseudonyms that I use for the two teachers are Mr. Thekiso and Mr. Ronaldo. I gave a brief academic background for each teacher in Chapter 3 which indicates each teacher's knowledge about the new curriculum. Mr. Thekiso is the teacher who has a Further Diploma in Education, and Mr. Ronaldo has a B.Sc Honours degree. However, exposure to the new curriculum in

accordance with the teachers' qualifications does not necessarily mean that teachers will employ practices that resonate with the new curriculum. Possibilities for employment of new curriculum practices still exist for teachers who have not had any exposure or had only little exposure to the new curriculum, while many teachers who have had much training stick to old curriculum practices.

Mr. Ronaldo's data was collected before the new curriculum was introduced in grade 10, and this is the existing data that I used for my study (see Chapter 3). Mr. Thekiso's data collection coincided with the introduction of the new curriculum in grade 10, and it is the data I collected through the five lessons I observed Mr. Thekiso in practice.

4.2.1 Mr. Thekiso's lessons

I observed five lessons in Mr. Thekiso's class. There were about 30 learners in each lesson and learners were seated two per desk but not necessarily working as a pair. Two topics made up the five lessons. The first was sketching hyperbolic graphs and determining their equations. The second was trigonometry, where learners were introduced to basic trigonometric ratios. Mr. Thekiso always stated upfront what the lesson for the day was about, and went on to write the topic on the board for learners to see. Learners always kept their attention on what he was doing and did not write anything down until the end of the discussion. The lessons were dominated by questions and answers, following an IRE/F (Initiate-Respond-Evaluate/Feedback) structure (Brodie, 2004; Mehan, 1979). The teacher would ask a question (which is initiation), allow learners to give their responses, and give feedback or evaluate the learner's response. Thereafter, the IRE/F cycle would be repeated with another initiation by the teacher. After teaching a particular concept(s), Mr. Thekiso would give learners classwork, walk around the class to see what they were doing, and go to the board for a general class discussion on what he picked up as he was walking around the class. Towards the end of every lesson Mr. Thekiso would recap everything that the class had done on the particular day. Questions from the teacher dominated this session of the period and also followed an IRE/F structure.

When trigonometry was introduced in the fourth lesson, the teacher asked learners questions on basic concepts of trigonometry, for example, which side is the hypotenuse and how to identify that side, which side is opposite or adjacent to which angle. Mr. Thekiso used these questions to determine how much learners knew about trigonometry. In general, Mr. Thekiso maintained a moderate, non-threatening tone of voice throughout the five days that I observed him teaching.

4.2.2 Mr. Ronaldo's lessons

There were four lessons that provided me with data to analyse Mr. Ronaldo's practices. These lessons, as I explained in Chapter 3, were taken from an already existing set of data. The class had about 42 learners, and the learners sat one per desk with desks arranged in rows. One topic was covered for the week of data collection: factorising the difference of squares. Mr. Ronaldo would always start his lessons from particular concepts that gave learners problems the previous day. Much of the time was spent on whole class discussions, learners coming to the board to write and explain their thinking and the teacher engaging the whole class on particular concepts.

It was evident that learners were previously given work to do on factorisation of differences of squares, and the teacher was correcting that work through these lessons. The teacher called out the number of the question to be dealt with, wrote that on the board and engaged learners in finding the solution to the problem. The teacher dealt with both the correct as well as the incorrect answers that came from learners. The next question would follow immediately after the solution to the preceding question was done. Mr. Ronaldo often used a loud voice, sounding passionate and a little aggressive when addressing learners. Despite the somewhat aggressive tone, learners still engaged with him and with each other at ease.

To investigate how the two teachers taught in relation to the new curriculum, I will look at all the lessons for both teachers and give a quantitative as well as a qualitative analysis of the lessons. Mr. Ronaldo's approach, on the surface, seemed more reform-oriented,

and Mr. Thekiso's more traditional. However, a deeper analysis will show that each teacher's practices contained aspects of both reform and traditional teaching.

The following table gives the time each teacher spent on each lesson:

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	**Total time**
Mr. Thekiso	45	45	25	40	55	**210**
Mr. Ronaldo	40	38	55	41	-	**174**

Table 1: Lesson times (in minutes)

This table helps to interpret the number of practices given in Table 2. This table also shows that slightly less time was analysed for Mr. Ronaldo because only four lessons were analysed. However, the amount of time and number of practices do not necessarily correlate strongly. The same teacher can have more practices for one lesson and fewer practices for another lesson given almost the same number of minutes.

4.3 The teachers' practices

Table 2 gives a summary of the practices that came up in the lessons for the two teachers. It should be noted that the numbers appearing in the table may be affected by the number of lessons that each teacher had (see Table 1).

I use a count in my table instead of percentages to give an actual number of occurrences for each particular practice. I decided against the use of percentages as they can sometimes be misleading when dealing with small numbers. Thus, the numbers appearing in the table are actual number of occurrences of practices per teacher.

I have also used a variety of colours in the Table 2. I use red to indicate obvious, quantitative similarities between the two teachers. Blue is used to indicate obvious differences that occurred between the two teachers. To ascertain similarities and differences, I looked at the total number of occurrences for each sub-category for the two teachers and decided on similarity if the totals were close to each other and difference if the totals were further apart. I did consider the fact that Mr. Ronaldo had four lessons compared to Mr. Thekiso's five lessons. I used black for occurrences

that did not match my description for obvious similarities or differences between the two teachers, but were rather minor differences or similarities. What follows is Table 2.

Practices	Form		L1	L2	L3	L4	L5
Providing meaning	Inserting correct language/terminology	T1	4	1	3	6	1
		T2	4	2	2	1	-
	Writing on the board	T1	11	6	6	9	11
		T2	12	4	9	12	-
	Raising the task level	T1	0	0	0	0	0
		T2	3	0	1	2	-
	Using prior knowledge	T1	7	4	1	3	3
		T2	1	0	2	5	-
Integrating topics of the lesson		T1	3	4	2	1	1
		T2	0	0	0	0	-
Checking learner understanding	Getting learners to explain themselves	T1	6	0	2	1	0
		T2	3	6	0	4	-
	Asking a learner to repeat/re-explain	T1	0	0	0	0	1
		T2	0	0	1	0	-
	Redirecting input	T1	1	1	2	0	3
		T2	8	13	4	0	-
	Recapping/summing up	T1	2	1	3	2	1
		T2	2	0	1	1	-
	Giving classwork	T1	2	2	1	2	4
		T2	0	0	1	0	-
Raising/maintaining interest	Breaking monotony of the lesson	T1	6	3	3	3	3
		T2	2	1	0	1	-
	Giving advice	T1	4	3	2	3	2
		T2	5	2	4	2	-
	Working at a moderate pace & tone of voice	T1	Done throughout				
		T2	Varies				
Pushing for justification	Doing self-evaluation	T1	0	0	0	0	0
		T2	9	3	0	3	-
	Handling correct/incorrect responses	T1	6	0	2	1	0
		T2	3	6	0	4	-

Table 2: Summary of practices **T1 = Mr. Thekiso, T2 = Mr. Ronaldo**
L1 – L5 = Lessons 1 to 5

4.3.1 Differences between the two teachers

I am looking at differences between the two teachers not to judge which teacher is better, but to give an indication that there are a variety of practices that different teachers can and do use at particular times of their lessons. The most obvious differences occurring in the table can be seen in the sub-categories of raising the task level; redirecting input; giving classwork; working at a moderate pace; doing self-evaluation, as well as in the main category of integrating topics of the lesson.

Mr. Ronaldo raised the task level to provide more meaning to learners on a particular aspect of the topic. For example, he began lesson one with $k^2 - p^2$, and the main task in the lessons was understanding how to factorise the difference of squares and how to check the answer. After the expression was factorised, the class checked the correctness of the factors by multiplying them so as to check if those factors will give difference of two squares as the answer. Mr. Ronaldo then gave learners $a^2 + b^2$ to factorise, and asked them to do the same thing that they did with $k^2 - p^2$, that is get the factors of $a^2 + b^2$ and check if those factors will give $a^2 + b^2$ when multiplied. In doing this, Mr. Ronaldo was working on the conceptual meaning of factorisation – that the factors can be multiplied to give the original expression. Almost the whole lesson went on with learners coming up with factors such as $(a - b)(a + b)$, $(a + b)(a + b)$, $(a - b)(a - b)$, $(-a - b)(a - b)$ and testing their factors to see if they will yield $a^2 + b^2$. The level of the task was raised here in the sense that the concept that was being dealt with was factorising difference of two squares, though a different problem was put on the board. Despite the fact that none of the learners realised that the expression $a^2 + b^2$ is not a difference of two squares, there was a lot of thinking going on in learners trying to get the correct factors and testing them. If learners had thoroughly grasped the concept of this type of factorisation and that the difference is necessary for factorising, they would have realised that the expression could not be factorised. It may have looked like a waste of time to take almost the entire lesson on a single problem, but there was a lot that was happening during that time. Every time a learner came with an answer, Mr. Ronaldo would ask the particular learner if s/he tested his/her answer, and each learner tried to justify their answer by multiplying the factors. Testing one's answer goes with thinking of ways to justify your answer and informing other people why your answer makes sense.

Although the issue was not resolved by the end of the lesson, Mr. Ronaldo still did not tell the learners that the expression $a^2 + b^2$ does not factorise. Instead, he instructed learners to take the problem home and work on it and bring the solution in the next lesson and be prepared to test their solutions. By telling learners that they must bring the solution and test it suggested that he wanted learners to think deeply about what they were doing and prepare themselves to justify their answers, which is one of the mathematical practices that the teacher was developing in his learners.

Later in the week, Mr. Ronaldo went on to problems such as $b^2 - 81$, $12b^2 - 75c^2$, $(p + q)^2 - v^2$, $(a + b)^2 - (c - d)^2$ and $36a^2 - 25(a - b)^2$, which were all factorising a difference of two squares but were at different cognitive levels. This variety in the task levels helped learners to be engaged in the lessons and provided more meaning to the discussions that were held on the topic of difference of two squares. Important issues came up as a result of this, issues such as perfect squares and what makes an expression to be a perfect square. These came to the fore and were extensively discussed. I will elaborate more on this aspect under similarities between the two teachers. The discussions held during the lesson helped the teacher (and the learners to some extent) to identify gaps in learner understanding of concepts that they had dealt with previously. Through discussions of these gaps, learner understanding of certain concepts could be enriched.

The sub-category of self-evaluation also occurred only in Mr. Ronaldo's lessons. He kept on pressing learners to test their answers before they could be certain about them. His learners understood that when they gave an answer, they would be asked if they had tested that answer. After a learner went to the board to factorise the expression $12b^2 - 75c^2$ and got an answer of $3(4b^2 - 25c^2)$, another learner, Manzi, came to the board to test it. Manzi's test was incomplete, until another learner, Lebogang, intervened. The following extract shows how the learners went about testing the answer. Mr. Ronaldo had by this time instilled in his learners the practice of testing their answers before getting convinced that their answers were correct or not, and this is what transpired as will be seen from the next extract:

1	Teacher	Remember we must come back to test, people we must come back to test, yes, Manzi
2	Manzi	(*Inaudible*)
3	Teacher	This is the right answer
4	Manzi	Let me come and show you, Sir
5	Teacher	Yes come and teach us what...(*learners are making noise*) hayi [no], people give Manzi a chance please (*learners laugh*)
6	Manzi	You see, if you take 3 and 4, it give 12 neh (*learners=ja*) so is 12b squared neh, if you take 3 and 25, it gives you 75, is a correct answer
7	Learners	Yeahhh (a*pplauding Manzi*) Manzi, Manzi (*shouting his name*)
8	Teacher	Very nice Manzi, but can this...(*pause*) Lebogang has shown us neh, 4b squared minus 25c squared, can be broken up into two smaller factors and we all say yes when we multiply these two we get it, yes, what do you want to say (*responding to the learner whose hand is up*)

***Extract 1*: Self-evaluation**

In the first turn, the teacher emphasised testing whether the answer that learners gave was correct or not. The learner's test was valid, in that he multiplied out the two factors, however the factorisation was incomplete. When the teacher asked them if the answer was correct, some learners said yes and the teacher wanted them to justify their answer. One of the learners, Lebogang, had earlier indicated that the answer that was obtained was not complete, as it could still be factorised, i.e. $3(4b^2 - 25c^2)$. This was proof that Lebogang had worked on the problem and was convinced that the solution could be taken further. She then gave her answer as $(2b + 5c)(2b - 5c)$, but left the factor 3 out. Coming to the board meant that Lebogang had tested her answer and it worked. It was then that Manzi decided to come and give a justification for the first answer, as can be seen in turn 6 when he multiplied out $3(4b^2 - 25c^2)$. He provided a justification by multiplying factors that were initially obtained to show that those factors can give the original expression they worked from. However, the point that the teacher wanted to raise and wanted learners to realise was that leaving the factor 3 out in the expression $(2b + 5c)(2b - 5c)$ makes it an incomplete solution for the original problem $12b^2 - 75c^2$.

Doing self-evaluation on work that you have done can help you to know why you think you are correct and why your response should make sense to other members of the community in class. It

is this reasoning that learners should provide and be prepared to share with their teacher as well as with their classmates. This can also help learners to bring in constructive arguments that provoke some thought-processes even if their answers are wrong. This practice of encouraging learners to evaluate themselves can be internalised by learners and can make teaching and learning more meaningful. If internalised, learners can know what is expected of them in learning about mathematics, know that mathematicians think and reason about what they are doing, and know how and why mathematicians justify the contributions they make when doing mathematics. Kilpatrick et al (2001) raise the importance of answers being right because of the sense that these answers make and a particular line of reasoning that they follow. When learners do self-evaluation, they put themselves in a position of developing the sense and reasoning that they can provide for the answers that they give in class.

The other major difference between the two teachers was on integration within mathematics as a subject, as well as across the different subjects or learning areas. Integration is a reform practice and it happens when a teacher links topics within other topics in mathematics, and across the different subjects such as mathematics and science or mathematics and English. This integration only happened in Mr. Thekiso's classes, and it helped to provide more meaning when learners struggled with particular concepts. When teaching trigonometry, Mr. Thekiso referred learners to English when they couldn't understand which of the sides of a triangle should be the adjacent side. After agreeing with them on what the word adjacent in English meant, he succeeded in helping learners understand which side was the adjacent side. This integration helps in highlighting the interconnectedness of mathematics as a discipline and between mathematics and another subject. Integrating within mathematics occurred when Mr. Thekiso compared a hyperbola to the straight line graph. This integration helped to explain why a hyperbola does not have x-intercepts.

The other difference that emerged between the two teachers was the manner in which they redirected their learners' inputs or responses. Mr. Ronaldo did this more often to assist him to work with a variety of contributions. Evidence of this occurred when he dealt with, for instance, factorising $12b^2 - 75c^2$. Extract 1 above shows part of such an interaction. He dealt with correct and incorrect answers in the same way as he kept on asking learners whether they agreed with inputs made by other learners and asked for more inputs from learners. Mr. Ronaldo handled

correct and incorrect answers in the same way so as not to make answers too obvious for learners, but rather to encourage learners to provide justification of their answers. In addition, working with different views from learners follows some logic of reaching a general conclusion, and can help learners see that one does not generalise from a single factual statement. This is a practice that mathematicians work with and helps to bring reasoning into the mathematics classroom (The Rand Mathematics Panel, 2002). Mr. Thekiso also redirected learners' input and responses, though in his case it was mainly to search for the correct answer and not necessarily to press (Kazemi & Stipek, 2001; Brodie, 2004) learners into justifying their responses and helping to reach some general conclusion. In his interview, Mr. Thekiso argued that he worked with a variety of learner responses, be they correct or incorrect ones. To emphasise his point, he referred me to an instance when he did that in a trigonometry lesson. However, the approach he employed in that instance was reminiscent of an IRE/F structure as he kept on calling learners to the board to write answers, and rejected all the wrong ones in the process until he settled for the correct one.

Giving learners classwork was more predominant in Mr. Thekiso's lessons. After giving learners some work to do in class, he would move around to check if learners understood what had been discussed. It was from moving around and watching the learners' books that he would pick on what they were writing and go to the board to address the whole class. The discussions could involve correct ideas that learners had written in their books and would be of interest to the whole class. Important aspects of those would be reemphasized. The teacher also attended to common mistakes that learners were making as they continued with their work. It is through such discussions that a teacher can work with the learners' ZPD (Vygotsky, 1978) during the course of the lesson. Looking at the learners' books as they work, and discussing their work with them puts the teacher in a better position to see where learners are positioned as far as their ZPD is concerned, and enables him to move them from actual to potential development (Vygotsky, 1978). Mr. Ronaldo gave classwork to learners once to help learners understand the concept of a perfect square. This he did by working with ordinary numbers in table-form and allowing learners to compare table columns to identify perfect squares. However, he asked for a report back from the learners to fill in the table, he did not circulate to check what their strengths and weaknesses were.

There are other differences that occurred in the two teachers' lessons but were not as major as the ones I have discussed. The two teachers both used learners' prior knowledge in a variety of ways. Mr. Thekiso gave his lessons a structure that always used prior knowledge as departure for every lesson. He began the section on trigonometry by asking learners questions on what they think trigonometry is all about. When the learners started giving their answers such as 'angles, triangles, and so forth', he then built on those answers to shape his lesson. Mr. Ronaldo also used prior knowledge though not as much as Mr. Thekiso, and not necessarily at the beginning of his lessons. Mr. Ronaldo used prior knowledge when learners were struggling to understand what a perfect square is, and he then referred them back to ordinary numbers to explain why a number is a perfect square.

If a teacher has a sense of what learners tend to find easy or difficult as well as the difficulties they experience with particular topics, it puts the teacher in a position of knowing how to select concepts that will elicit prior knowledge to provoke learners' thinking. When learners in Mr. Ronaldo's class struggled to identify $(p + q)^2$ as a perfect square, he used examples that were familiar to learners and easy to work with, encouraging learners to chorus answers in some instances. One of those examples was to explain why the number 4 is a perfect square, to put emphasis on multiplication of a number by itself. Through the use of such examples, learners were helped to realise what makes an expression to be a perfect square.

When learners in Mr. Thekiso's class struggled with understanding whether the graph of a hyperbola has x-intercepts or not, and to explain why it has or does not have x-intercepts, he referred them to the graph of a straight line, and tried make links between the two graphs with respect to the concept of x-intercept. Fennema and Romberg (1999) argue that learners must have opportunities to relate their learning to their existing knowledge in ways that support the extension and application of that knowledge. It is in this way, they argue, that students can learn with understanding.

The breaking of monotony during a lesson formed part of the two teachers' practices in maintaining the interest of learners in what was being discussed at the time and keeping their concentration. This happened far more in Mr. Thekiso's class than Mr. Ronaldo's. Breaking

monotony can help learners maintain interest on what is being discussed and know when to make valuable inputs. Cracking a joke, using related analogies or relating the topic to a real life situation can help draw the attention of learners in a lesson. After working extensively with sketching the graph of a hyperbola, Mr. Thekiso wanted to introduce the concept of determining the equation of the graph and referred learners to an analogy of coming to school in the morning, and the turns that learners make at particular street corners. He then asked learners about the corresponding turns that they will make if they go home from school in the afternoon. He wanted to make learners aware that a right turn to school in the morning would become a left turn in the afternoon when they go home. This analogy was helping learners to understand the notion of 'reversibility', which Mr. Thekiso was applying in introducing the topic of determining the equation of a graph.

When Mr. Ronaldo dealt with taking out the common factor from $12b^2 - 75c^2$, he used the phrase 'vumani bo?', which is a phrase normally used by traditional healers. The phrase literally means 'do you agree?'. The usual response to this phrase should be 'siyavuma', to mean 'we do agree'. In literal terms, for one who has consulted a traditional healer not to respond accordingly would mean that you do not respect the ancestors' revelation and yet you have consulted them by coming to a traditional healer. In Mr. Ronaldo's case, he happened to be the more knowledgeable person in class, and learners had to agree with him on what he told them. The learners knew that Mr. Ronaldo was not a traditional healer and that is the reason why they laughed when he made those utterances because they knew that he was just bringing fun into the lesson. But Mr. Ronaldo used this context to put a challenge to the learners to agree with him even if they had reservations on what he told them. Other than raising the interest of learners in the lesson, the learners' thinking and participation in the lesson was being put to the test to see if they agree with everything that their teacher tells them.

Learners in Mr. Thekiso's class internalised the phrase that 'if you don't understand the question, then you don't know the answer'. Internalising the statement may have helped learners think more deeply about questions that their teacher posed in class before they gave their responses. Encouraging learners through these types of statements can influence the learners' thinking and reasoning about what they do in class. Mr. Ronaldo, on other hand, insisted that learners 'test' their answers before they give them, and the learners could have internalised the practice of

‘testing’ their answers before they externalised them for public scrutiny. This internalised practice was evidenced in extract 1 of this chapter, and more evidence of this practice will be provided in extract 4. This practice can help learners think deeply about their answers and how to justify them, thereby developing their reasoning skills.

Mr. Thekiso managed to maintain a moderate pace in his lessons with a friendlier tone of voice. There was never any instance in which he raised his voice to shout at learners or indicate losing his temper/patience with the learners. This practice helped him create a classroom atmosphere in which learners felt free and relaxed, thus providing an atmosphere that was conducive to making contributions. Despite the fact that Mr. Ronaldo raised his voice in his lessons, sometimes shouting at learners, he still managed to get learners make contributions in the lessons. The shouting was more often a passionate demand for justification of answers from learners.

The differences that I have outlined in this section show that there were a variety of practices that the two teachers employed in their lessons. These differences should not necessarily be seen as dichotomies as the differences do not create situations of ‘either … or ’. The two teachers decided what practices to employ in their classes to help develop learners’ thinking. Whichever practices the two teachers employed could work positively in some instances and help them develop a sense of meaningful thinking in learners. These differences suggest that certain practices from teachers can be developed, wherever possible, to help them teach in ways that resonate with what the new curriculum encourages. Practices that resonate with the new curriculum can help improve involvement of learners in the lessons, and can hone their reasoning skills.

These differences also suggest that Mr. Thekiso used more traditional practices in traditional ways, as when he used an IRE/F structure in his lessons, and he also used some reform practices in reform ways, for example integrating topics of mathematics. In addition, Mr. Thekiso also used reform practices in traditional ways, as when he called learners to the board to explain their thinking and not engaging them in ways that promoted thinking and reasoning, but merely rejecting or affirming the learners’ answers. On the other hand, Mr. Ronaldo used traditional practices in reform-oriented ways by his tone, since learners were still constructively engaged in the lessons despite his ‘intimidating’ voice. As opposed to traditional teaching, Mr. Ronaldo’s

way of raising his voice did not instill fear in his learners, as learners got on very well with their continued participation in his lessons. Mr. Ronaldo also used traditional practices in traditional ways as was the case when he encouraged learners to chorus answers. Chorusing of answers is a practice that does not resonate with the new curriculum. Mr. Ronaldo did indicate in the interview, however, that he tries to refrain from using traditional methods of teaching in his classes but becomes helpless at times. To explain why he sometimes resorted to traditional methods, Mr. Ronaldo had this to say:

"… and sometimes I think teachers who teach without meaning are more successful at times, you know, because a child would do that correctly, but does he understand what he's doing, half of them don't, you see. Sometimes you pressed for time, you cannot always get the reasoning, and you resort, or other teachers might resort, even me at times maybe, I resort to that, you know, teaching without the meaning".

This extract suggests that Mr. Ronaldo is aware that he includes traditional methods in his teaching for reasons he has given as when pressed for time. There were also instances where Mr. Ronaldo used reform practices in reform ways, as when he pushed learners to justify their answers.

Not all teaching practices can promote reasoning, but the practices that did not promote reasoning in either of the two teachers' lessons also give ideas for further development in teacher practices that can be employed in accordance with the new curriculum. The next section deals with similarities between the two teachers' practices and the influence that these practices can have on the learners' contributions in class.

4.3.2 Similarities between the two teachers

In this section, I look at similarities between the two teachers' practices. Some of these similarities are only quantitative because when I looked at them from a qualitative point of view, I realised that there were differences within them. Similarities provide me with a sense of knowing that there are common practices that many teachers can employ in their teaching to suit reform methods of teaching even though there may be differences within these practices relating to contextual aspects.

The two teachers in my study both showed a mixture between traditional practices in their teaching and reform-oriented practices. This mixture of practices concurs with the argument I raised in the previous section that traditional practices will always have a place in the new curriculum. It all depends on how these traditional practices occur in a classroom situation.

There are seven occurrences of similarities that appear in Table 2. The first is the use of language/terminology in the two classes. Language is an important tool in mathematics that can help learners develop their reasoning as well as their communication skills. Mathematics also has its own discourse (Setati & Adler, 2001), and when teachers put emphasis on the importance of the correct use of mathematical language, this can help learners to behave and act like mathematicians. Mr. Thekiso asked learners what the other name for a Cartesian plane is, and some learners responded to say it is a system of axes. Mr. Ronaldo emphasised the word 'difference' in the difference of squares. Difference is a word in ordinary English language that means not being the same, whereas in mathematics it means subtraction. Being conversant on the use of the word's mathematical meaning can help learners understand why some algebraic expressions can be factorised whilst others cannot. That learners struggled with factorisation of $a^2 + b^2$ in Mr. Ronaldo's class is an indication of showing how important the language and terminology of mathematics is. Other than testing their factors to see if they are correct, if learners understood that the word 'difference' implies a minus or subtraction sign between terms, they would have realised that $a^2 + b^2$ has a plus or addition sign between the terms and can therefore not be factorised. Mr. Ronaldo deliberately avoided telling learners that only an expression of difference of two squares can be factorised, but rather pushed learners to think about the structure of the problem, and through that finding factors that would give $a^2 + b^2$ would realise that it could not factorise. In this situation however, learners seemingly focused only on the two squares and disregarded the sign between the squares. They also did not correctly evaluate the factors that they got, that those factors would not revert back to the original expression of $a^2 + b^2$ when multiplied.

The second similarity between the teachers relates to writing on the board. The numbers in the table are a reflection of how often the two teachers went to the board to write something, be it a word, sentence, or a sketch. Talking without writing can make learners lose some of the information discussed in class. Other than for retention purposes and having to remind oneself

about previous discussions on a particular topic, information written on the board puts it in the public domain. If information is in the public eye it will be there for other members of the learning community (Lave, 1996) to critique and give their opinions. This critiquing can raise concrete arguments that develop the learners' thinking and reasoning.

Even though writing on the board was a common practice between the two teachers, the two teachers did it in different ways. Mr. Thekiso would on many occasions write on the board when he had to recap or emphasise a particular aspect of the lesson. The following are some of the things that were written on the board when Mr. Thekiso was dealing with the graph of the hyperbola:

<u>Hyperbola</u>
k is positive
1^{st} and 3^{rd}
k is negative
2^{nd} and 4^{th}

On the board there was also drawn a system of axes with all the four quadrants labeled I, II, III, IV in a clockwise direction from 1 to 4 to help make a link with the above information. This writing can help learners remember information for a longer period because it was not only told, but could be seen as well. This can help learners know why a hyperbola occupies particular quadrants for certain values of *k*, and why it does not occupy the others. Secondly, for learners who missed any information when the teacher or another learner said it, there is information available on the board to update oneself and be on par with everyone in as far the discussion was concerned. Many of the things that were written on the board in Mr. Thekiso's class were correct statements. If a learner came to the board and wrote a wrong answer, the answer would be erased before other learners would be invited to give their answers. This process of looking for a correct answer would continue in this manner until the correct answer was obtained.

Mr. Ronaldo would write on the board whichever answers the learners gave, be they correct or incorrect, and he also allowed learners to share their thinking with the class by writing their

solutions on the board and explaining their thinking. Leaving wrong answers in the public eye for discussion can help the teacher as well as the learners to identify errors and misconceptions that other learners make when giving their solutions. It is also through discussing these errors and misconceptions, which Mr. Ronaldo did, that learning takes place and learners can engage one another in dealing with these errors and misconceptions. Mr. Thekiso wrote wrong answers only once in the five lessons I observed, and this was when he gave learners a triangle with no right-angle and asked them to work out trigonometric ratios from that triangle. This triangle was given to learners to check if they understood the basic principles governing trigonometric ratios. In essence, the importance of having a right-angled triangle as a requirement when working with trigonometric ratios. However, learners were not given the opportunity to engage, through discussions, with the wrong answers, thus not enabling them to know why those answers were wrong. Instead, it was the teacher who gave a full explanation on why the learners' answers were wrong.

Nesher (1987: 33) argues that "a good instructional program will have to predict types of errors and purposely allow for them in the process of learning". This concurs with what Brodie (2005) argues for, that errors are often "remarkably reasonable when viewed from the perspective of how the learner might be thinking" (p.37). Learners' misconceptions can help them develop into becoming better thinkers and doers of mathematics, if teachers ask learners to explain their thinking when they produce these misconceptions (Brodie, 2005). This was a characteristic of Mr. Ronaldo's lessons rather than Mr. Thekiso's. Evidence of discussing errors/misconceptions will be seen in turn 23 of extract 3 when Mr. Ronaldo asks a learner to engage with an error produced in the lesson.

The third similarity, which I have already highlighted above, is getting learners to solve problems on the board and explain their thinking. If done more often, getting learners to explain themselves can help improve the learners' confidence and self-esteem, as well as their mathematical thinking. The two teachers both called learners to come and explain their answers on the board but did it in different ways. Again, this was a practice only similar in quantitative terms, but providing a difference in the manner in which the two teachers employed the practice. In Mr. Thekiso's class, the learner on the board would usually talk to other learners or to the teacher, without any

constructive interaction between them. Whereas in Mr. Ronaldo's case, the other learners would engage with what the learner explaining on the board was doing. The following two extracts from the two teachers' classrooms provide evidence of how the two teachers dealt with learners' explanations in different ways.

9	Mr. Thekiso	Somebody from group one, somebody from group one, can you come forward (*a learner approaches the board*), and then, don't just draw the graph, try to explain to your classmates, how you go about, in plotting that particular graph
10	Learner	First we find the y-intercept, y-intercept is *c*, the sign of the y-intercept is equal to two. (*Writes c = 2 on the board*). And then we find the gradient, three over four (*writes* $m = \frac{3}{4}$ *on the board*). Then we plot the graph.
11	Mr. Thekiso	That's quick
12	Learner	(*Continues to work on the board*). We first plot the y-intercept, positive two, and we go, oh (*rubs off 2 and writes it again underneath*), then we go upwards counting three times. Eh, in the y-intercept, one, two, three. Then we go positive four times, to the x-intercept, one, two, three, four, then positive four, then we plot the graph (*drawing a slanting line*)
13	Learners	(*Laugh*)
14	Mr. Thekiso	Ja [yes], uyazi [you know], you know, honestly speaking, I can't sketch a straight line graph. He can, but I cannot, I cannot. Eh, eh, unfortunately we don't have enough space here. Eh, (*rubs off drawn line*). Can we go back and revisit, he said two, one two, three, eh, your positive four, we don't need (*inaudible*). Maybe, the diagram that we have on the board, is a rough sketch, but if you draw it in your books, it must be accurate. If you draw a line, make sure that you use a ruler. Okay, fine.

***Extract 2*: Mr. Thekiso's class, learner explaining from the board**

15	Lebogang	*b* times *b*...(*she wrote ab in brackets plus ab in brackets, she then multiplied a times a she got a squared and the b times b she got b squared*).
16	Learner	Never, never.
17	Learner	Angeke (*Never*)
18	Lebogang	Yes
19	Learners	(*Mumble*)
20	Lebogang	Yes, positive times positive is positive (*she points at the figure while*

		explaining)
21	Mr. Ronaldo	Are we…listen, who wants to say something (*inaudible*)…Lebogang (*calling upon another Lebogang to respond*)
22	Learner	If you say *ab* in brackets it means it is the same thing, because you can`t tell me *a*, *a* times *a* and you have *ab*, it's impossible, Sir….
23	Mr. Ronaldo	So what…what should she be saying…what should she be saying, it shouldn't be said? What, what do you see there?
24	Learners	Positive (*chorus*)

***Extract 3*: Mr. Ronaldo's class, learner explaining from the board**

The two extracts show that when Mr. Thekiso invited a learner to the board, the learner's explanation had the potential to engage other learners. However, Mr. Thekiso did not create the conditions for that interaction to take place. He took over from what the learner had done, and went on to conclude the discussion about what the learner had done on the board. Concluding the discussion in this manner without encouraging further discussions from other learners has the potential of stifling learners' thinking and not bringing out whichever ideas that could still be available for promoting further reasoning. The explanation by the learner in turn 12 shows that there is evidence of thinking in what the learner was saying but this thinking was not given a chance to develop further. In Mr. Ronaldo's case, it was other learners who objected and engaged with what was done on the board, as can be seen in turns 16, 17 and 22, with the teacher still in control and facilitating the interaction. The teacher did not tell learners whether the answer was right or wrong, maintained the openness of the discussion and gave learners opportunities to make contributions, including the learner who was explaining from the board. If learners are not given enough chance to interact with each other, it limits their reasoning and thinking and might also limit the number of contributions that a teacher can get from learners, thus adversely affecting their confidence and self-esteem. The two extracts show that Mr. Thekiso's approach was reminiscent of employing low-press questions whilst Mr. Ronaldo's approach was that of employing high-press questions (Kazemi & Stipek, 2001). High-press questions, as opposed to low-press questions, force learners to apply their reasoning when they give answers, hence building their confidence and self-esteem.

Confidence and self-esteem are characteristics that develop with time, and when learners are allowed to express themselves verbally in explaining what they have written on the board and have constructive interactions between them, this will help them develop those characteristics. Lampert (2001) argues for learners to evaluate their own thinking in three ways: by privately reflecting on

what they are doing, which carries some thought processes; by talking about it in the local community, which in this case would be in the classroom; and by presenting their ideas to the class for public discussion under the guidance of the teacher. It is in this way that learners can develop the ability to share their ideas and respect each other's opinions in their discussions.

The fourth similarity occurred when the two teachers asked other learners to repeat or explain what had already been discussed. This is important in two ways if it is made a regular practice. First it helps to encourage concentration of learners in class, as they will know that they can be asked to repeat or re-explain what had already been said. Second it can force a learner to think about what s/he is been asked to say and allow him/her to make his/her personal opinion known in agreeing or disagreeing with the said information. The two teachers did this differently. Mr. Thekiso would do it for two reasons: To emphasise the correct answer, or get a learner to correctly phrase a statement s/he made, as when one of the learners battled with pronouncing the word hypotenuse. Mr. Ronaldo would ask learners to repeat or explain what had been discussed to facilitate a difference of opinion as was the case when one of the learners disagreed on the factors of $(a + b)^2 - (c - d)^2$.

The next similarity was on recapping or summing up a part of the lesson or the whole lesson. Recapping/summing up, discussed earlier under the practice of writing on the board, can occur when the teacher wants to remind the class about what had been discussed previously, or when s/he wants to check on the learners' understanding. In checking on the learners' understanding, the teacher might use questions. The manner in which the teacher asks these questions might also lead to an IRE structure, as was often the case with Mr. Thekiso. Asking questions might help the teacher invoke the learners' thinking (Kazemi & Stipek, 2001) and help lead to discussion of disagreements, dissatisfactions or arguments that learners might raise. This happened in Mr. Ronaldo's class after he had raised the task level in class and wanted to conclude the process, and one learner raised her dissatisfaction. The following extract shows how he dealt with the situation when learners battled with factors of $(a + b)^2 - (c - d)^2$. Some learners failed to understand how the second term $(c - d)^2$ becomes $(c - d)(c - d)$ when it is factorised. The last line shows one learner's reaction to show her dissatisfaction.

25	Mr. Ronaldo	So, what should I see here?
26	Learners	*c* minus *d* (*chorus*)
27	Mr. Ronaldo	*c* minus *d*, and I should see c minus …
28	Learners	*d* (*chorus*)
29	Mr. Ronaldo	I'm putting it in brackets here, can you see?
30	Learners	Yes (*chorus*). Why?
31	Mr. Ronaldo	Why? Because it's in brackets there? This one too, I could have used the bracket here. It looks confusing. Let's just rewrite it. (*Erases the expression ((a+b)-(c-d))((a+b)+(c-d)) from the board and replaces it with [(a+b)-(c-d)][(a+b)+(c-d)]*
32	Lentswe	Sir, check it!

***Extract 4*: Internalised practice by learner**

The transcript shows Mr. Ronaldo trying to help learners with how the expression $(a + b)^2 - (c - d)^2$ can be factorised. He was doing this to sum up what the class had been discussing with respect to the expression. This did not augur well with some learners and the discussion was prolonged. The learners still failed to see how $(c - d)^2$ becomes $(c - d)(c - d)$ when factorisation is done. They confused $(c - d)^2$ with $c^2 - d^2$, and as a result expected $(c - d)^2$ to give $(c - d)(c + d)$ as its factors. Learners failed to realise that $c^2 - d^2$ is an expression of difference of squares whilst $(c - d)^2$ is not.

Although Mr. Ronaldo thought he had summed up the concept of factorising difference of two squares and dealt with the expression $(a + b)^2 - (c - d)^2$, some learners were still not happy about the teacher's solution. The extract below, which follows immediately from the one above, shows what transpired, when there were still learners prepared to engage the teacher in arguments by challenging the teacher's answer and stating what they, the learners, didn't agree with. The challenge is evident in the last two lines of the extract.

33	Mr. Ronaldo	Now if you see it there, why don't you see it here? Here I must take *a* plus *b* and times it by *a* plus *b*. What is *a* plus *b* times *a* plus *b*?
34	Learners	*a* plus *b* squared. (*chorus*)
35	Mr. Ronaldo	I can write it *a* plus *b* squared.
36	Learners	Yes (*chorus*)
37	Mr. Ronaldo	What's a negative times a positive?
38	Learners	Negative. (*chorus*)
39	Mr. Ronaldo	What is *c* minus *d* times *c* minus *d*?
40	Learners	*c* minus *d* squared.
41	Lentswe	Never! It is (*inaudible*).It is positive!
42	Learners	Never! It is (*inaudible*).It is positive, Sir.

***Extract 5*: Challenging teacher's input**

The above extracts are an indication of learners who had somehow internalised the practice of challenging an input or answer and being prepared to stand for what they strongly believed in, which is an aspect uncommon in other mathematics classrooms. These learners pushed other learners and the teacher by challenging the teacher to justify his answer, an answer that other learners in class agreed with, hence the question 'why' from learners in turn 30 and the phrase 'Sir, check it' by Lentswe in turn 32. Mr. Ronaldo continued to give further explanation in extract 5, leading learners to chorus answers as he worked through the solution but Lentswe still disagreed with what the teacher had done as evident in turn 41. Other learners supported Lentswe in disagreeing with what the teacher had done, though it is not conclusive at this stage whether these learners really disagreed with their teacher or were merely giving their classmate support in forcing their teacher to justify what he was saying. Justification is one of the mathematical practices used in thinking and reasoning about mathematics (Rand Panel, 2002; Kilpatrick et al, 2001) and these learners are engaged in it.

We know from theories of learning that learners construct their own meanings of mathematical ideas, talk and symbols (Hatano, 1996), and this is probably why in turn 41 a learner disputes what the teacher says and other learners supported her in the next turn. This happened because of a misconception in the learners' thinking. Lentswe, in extract 5, and the learners who supported her, were not convinced by what their teacher gave them as a solution, and she went on to challenge the teacher's answer. As members of a community of practice, children learn to participate in the classroom practices (Lave & Wenger, 1991). They learn practices from the teacher as well from each other. The type of questions as well as the manner in which the teacher poses them can become part of those practices that learners participate in and later internalise (Vygotsky, 1978). When this happens, the arguments that learners get involved in, and the way in which they express themselves, will reflect their teachers' practices. Mr. Ronaldo often asked learners to test their answers and check if they do work, and this became something that learners internalised over time. This can help learners to think about why certain answers are correct and why they make sense, and also know why others do not make sense. The difficulty in this case is that the challenge came from a misconception, making it necessary for the teacher to find a way to challenge the challenge. This is one of the difficulties for teachers in trying to work with reform teaching practices.

The sixth similarity is on the advice that the two teachers gave their learners on how to go about understanding and doing mathematics. It is this advice that gives messages about what mathematics is. Both teachers put emphasis on the aspect of thinking in mathematics. Mr. Ronaldo advised his learners not to rush into giving answers, but rather give themselves time to think carefully about their answers before making them known. Mr. Thekiso also highlighted a similar aspect when he wanted his learners to explain why the hyperbolic graph does not have x-intercepts. He told learners that 'in mathematics, we think and we reason'. Though both teachers gave their learners advice, Mr. Ronaldo was the one encouraging it more often in his learners through his teaching practices by encouraging learners to test their answers. Wood (1995) argues that teaching is an interactive collective activity in which it is the intention of the one teaching to influence the development of his/her learners' thinking. It is this influence that Lave and Wenger (1991) refer to when they talk of legitimate peripheral participation. The learners listen and learn ways in which their teacher poses questions, how he presses on them to justify their answers, and how he goes about to generalise facts. They first learn this being on the periphery, and later internalise those and also apply them. An example of this was given in extract 4, turns 30 and 32, as well as in extract 5, turns 41 and 42 when learners challenged the teacher. This was a practice that their teacher employed in his teaching and learners eventually internalised it.

The last similarity is on handling correct/incorrect responses. As respectively discussed in the second and the third similarities of writing on the board and getting learners to explain themselves, this practice was only similar in quantitative terms but showed differences in the manner in which the two teachers employed the practice. While Mr. Ronaldo would work with both the right as well as the wrong answers, without making learners aware if their answers were correct or incorrect, Mr. Thekiso mostly alerted learners if an answer was correct or not correct. Not alerting learners about the correctness or incorrectness of an answer provided opportunities for learners to interrogate each other's answers and thereby promoted reasoning in learners.

4.4 Summary

The distribution of data in Table 2 between the two teachers shows two important features of the two teachers' practices. First there are common practices that the two teachers shared in their respective classes. I analysed seven occurrences that showed quantitative similarities between the two teachers – use of mathematical language, writing on the board, asking learners to explain their thinking, asking learners to repeat what had been said, recapping the discussion, giving advice, and handling correct/incorrect responses. The number of counts given in Table 2 may show almost equal numbers but the qualitative analysis gave different meanings to what those numbers imply. Looking at the category of calling learners to do and explain a problem on the board, for instance, Mr. Thekiso did call on them but did not press on them to justify their answers or explanations (Kazemi & Stipek, 2001) as much as Mr. Ronaldo did. Mr. Thekiso basically searched for a learner who could give the correct answer. If a learner came to the board and did not give the right answer, he would go on to call another one and continued in that manner until he got the learner who could give the right answer. A similar practice occurred when he posed questions to the class. He would continue to reject the wrong answers and kept on asking other learners until he got the correct response. So, despite this being a new curriculum class, there were signs of traditional teaching evident in the manner in which Mr. Thekiso conducted his lessons.

On the other hand, Mr. Ronaldo would call learners to the board to do problems and explain their thinking and reasoning. This he did with both the right as well as the wrong answers, without making learners aware that their answers were incorrect. This approach of handling learners' responses helped in improving the level of communication in class and learners were in a better position to externalise their thinking and reasoning. The practice gives an example of a reform practice used in a reform way. There were, however, instances wherein Mr. Ronaldo resorted to traditional methods of teaching as was the case when learners couldn't give the factors of $(a + b)^2 - (c - d)^2$. He resorted to showing learners how the problem should be done. There were also many instances where chorusing was a feature in Mr. Ronaldo's lessons. Chorusing is a practice that is more associated with traditional methods of teaching. However, traditional methods can still be used interchangeably with reform methods in strategic ways to develop thinking and reasoning in learners (Brodie, 2005). Mr. Ronaldo did demonstrate this when

explaining the concept of perfect square by working on a number of calculations some of which yielded perfect squares.

One reason why Mr. Ronaldo may have been able to develop lessons in ways that resonate with the new curriculum could be his exposure to new approaches of teaching that he learned through his studies, though he attributes this himself to a strong knowledge of mathematics[4] that he possesses. How strong knowledge in a subject contributes to teaching practices is an issue I believe that needs further research. There were quite a number of good, knowledgeable teachers in the old curriculum who produced good results in mathematics, but the issue here is what type of practices they employed to produce these good results. The new curriculum now recommends particular ways of teaching that are somehow different from the old teaching practices. However, traditional methods still have a place in reform methods of teaching. It will not serve the teaching profession any good by completely ignoring the value that traditional methods bring in teaching. There will always be opportune moments to use traditional methods in moving the lesson forward as when the teacher realises that learners are getting more confused and lost and have to be steered back into the lesson or when learners would not be able to give the right answer and the teacher has become aware of such situations.

There were also differences in the manner in which the two teachers employed practices in their classrooms – raising the task level, integrating topics of the lesson, redirecting input, giving classwork, working at a moderate pace and doing self-evaluation. The differences evident in the two teachers' practices provide resources to inform future implementation of practices in mathematics classrooms.

Both teachers had practices that worked well for them in their respective classes, but they also had practices that needed development as discussed in this chapter. Other teachers can learn from the two teachers in relation to practices that can benefit learners in a lesson about thinking and reasoning mathematically. The weak points from the two teachers can also help the teaching profession in thinking about ways that can help to improve on those practices that inhibit thinking and reasoning in mathematics. My next

[4] *Knowledge of mathematics* mentioned during the interview

chapter will provide a summary of my findings for this study as well as the implications and recommendations that I will make for further research.

Chapter 5: Conclusions, Implications, and Recommendations

5.1 Summary of Findings

This research study has looked at how teaching practices have developed in the context of the new curriculum. Teachers found themselves in the middle of curriculum developments that they were expected to implement and that were expected to influence their ways of teaching.

In Chapter 2, I described practices as patterned regularities in methods that mathematics teachers employ in their classrooms. I distinguished between teaching practices and mathematical practices, where teaching practices such as asking questions or writing on the board are more general and happen in all classrooms, whereas mathematical practices such as justifying, generalising, explaining and so forth are more specific. I explained that practices are social in nature; they are intellectual and they are practical (Brodie, personal communication, 2007). I drew from various literature to try and highlight how different authors understand the concept of practices (Mousley, 2003; Elbers 2003; Mehan, 1979; Brodie, 2004; Lave & Wenger, 1991; Lemke, 2001), and how these practices influence the teaching and learning of mathematical thinking and reasoning (Rand Panel, 2000; Kilpatrick et al; Brodie, 2002; Cobb, 2000).

In Chapter 3, I described the particular practices that emerged inductively from my data, informed by the theoretical perspectives, and in chapter 4 I used these practices to analyse the teaching in two teachers' classrooms. I did a quantitative as well as a qualitative analysis of the data to describe the two teachers' practices and found that there were similarities as well as differences in the two teachers' practices. Some of the practices do promote thinking and reasoning to a larger extent, whilst others promote it only to a lesser extent or do not promote reasoning at all. The analysis provided evidence

of both traditional practices and practices that resonate with the new curriculum in both classrooms.

The differences that I found between the two teachers' practices suggest that Mr. Ronaldo was more "reform-oriented", but there were still elements of traditional practices in his teaching. Reform-oriented practices related to how Mr. Ronaldo involved learners in his lessons. His manner of handling learners' responses encouraged thinking and reasoning in learners, which is a practice that resonates with the new curriculum. With regard to traditional practices, Mr. Ronaldo attributed use of those, during the interview, to pressures related to time. However, I have argued that time should not be a deterrent to promoting thinking and reasoning amongst learners. I have also argued that there will always be a place for traditional practices in reform-oriented teaching. For example, the IRE/F structure is often thought of as characterising traditional teaching, but how it is used can lead to extended learner thinking and therefore resulting in reform-oriented teaching (Brodie, 2005).

The differences in the two teachers' practices suggest that Mr. Thekiso was more "traditional" with elements of some reform practices in his teaching. One of the reform practices he used more often was when he integrated topics of mathematics as well as when he integrated mathematical topics with subjects or learning areas such as science or English.

Similarities between the two teachers suggest that there was a mixture between traditional practices and reform practices, though Mr. Ronaldo used traditional practices in more "reform" ways whist Mr. Thekiso mostly maintained traditional practices in his teaching, with some signs of "reform" practices. Even though the two teachers had similarities in practices such as 'writing on the board' as well as 'asking learners to come to the board to explain themselves', the two teachers dealt with these practices in different ways. Whilst Mr. Ronaldo would open discussions for both correct as well as incorrect answers without making learners aware which of the answers were right and which were wrong, Mr. Thekiso often rejected wrong answers and followed an IRE (Mehan, 1979; Brodie,

2004) structure to get the right answers. This 'difference in similarities' suggest that as teachers we may be doing similar things in our classrooms in different ways.
I also sought to understand the various contributions that learners make in class and how these contributions steered the flow of discussions in class. One of the powerful tools that I have found to support higher levels of thinking and reasoning amongst learners is when learners take up practices that their teachers use in class and use those to challenge one another, or challenge their teacher to justify his answers (Molefe, 2003). Challenge for justification can be done for two reasons. First, when there is disagreement between or among learners or disagreement between the teacher and learners and all parties need to resolve the matter through reasoning. Second, when the teacher demands more explanation or meaning from a learner. Mr. Ronaldo had taught his learners to test their answers before they put them up for public scrutiny. The learner who challenged him in one of his lessons showed that she had internalised this practice of testing answers and was willing to push her teacher to do what he always pushed them to do.

What was also important was how the two teachers handled learners' responses. Handling learners' responses as a reform-oriented practice requires that teachers open up for more discussions from learners even if learners did not initially come up with a correct response. Exchange of ideas, regardless of wrong answers, can bring discussions that can create room for construction of meaning (Heaton, 2000), thereby developing learners' thinking and reasoning. These discussions can bring valuable input that other learners will benefit from as they listen to their classmates or as they participate in the discussions. This creates opportunities for the learner to transform what s/he gets from the inter-psychological, which is between the learner and other learners or the teacher, to the intra-psychological, which is internalised learning (Vygotsky, 1978). By virtue of being members of a community of practice when in the classroom, learners (as apprentices) learn from the teacher (practitioner) and also learn from each other (Lave, 1996).

Over and above helping learners to develop their thinking and reasoning skills, exchange of ideas can also help the teacher to identify gaps in the children's learning that will put the teacher in a better position to deal with these gaps.

5.2 Answering my Research Questions

The first question that guided my research stated:

'What kinds of practices do teachers employ to teach mathematics?'

In response to the question, my research shows that the two teachers in my study used a variety of practices in their classrooms. Some of the practices were traditional whilst others were reform-oriented. Drawing on empirical data I have argued that not all traditional practices are problematic, and as teachers we cannot do away with such practices as they also have their place in the new curriculum. This therefore explains why elements of traditional teaching can be found in reform-oriented teachers, and elements of reform teaching can be found in teachers who mostly employ traditional practices. Brodie (2007) argues that "teachers who might not be reform-oriented do work with learner thinking in some ways" (p.1). Working with learner thinking is an aspect associated with reform teaching. I have shown that Mr. Ronaldo used traditional practices in reform ways, whilst Mr. Thekiso used reform practices in traditional ways. This therefore suggests that use of traditional practices and reform practices interchangeably and in ways that promote thinking in class can be encouraged amongst teachers.

The second question guiding my research was:

'What influence do these practices have on the learners' thinking and contributions in class?'

Certain practices, when internalised by learners, might help them develop their thinking and reasoning abilities. The one practice that learners in Mr. Ronaldo's class had internalised was to test their answers for verification. Testing answers involved thinking and reasoning about why a particular answer makes sense or not. This study adds to my findings in my Honours research study, and has shown how some learners internalised their teacher's practices and used those for their benefit and the benefit of the class. Earlier on in this section, I discussed challenging the teacher's input as one such practice. This practice also occurred in my Honours research and helped me understand the type of inputs that can help learners make sense of mathematics. On the contrary, when learners are not given opportunities to express themselves in ways that give other members in class the chance to engage with each other's input or thinking, their reasoning abilities might not be developed and this will not help them in becoming better mathematicians.

Classroom interactions can therefore create opportunities in the classroom that enhance the development of mathematical thinking and reasoning, if these interactions are effective. If these interactions are not effective, they might inhibit the development of mathematical thinking and reasoning among learners, thus producing learners who cannot justify, generalise, nor explain their results. In encouraging learners to 'test' their answers, Mr. Ronaldo was trying to instill in his learners, a sense of knowing why their answers were correct or not, thereby developing their reasoning skills. Encouraging learners to know why their answers are right helps their reasoning and also helps the teacher to know how to support learners' further reasoning.

5.3 Limitations of my study

I have described a number of practices that two teachers employed in their respective classes. These practices may yield positive results for some teachers and the opposite for other teachers, depending on how these practices are used in particular classrooms. Different teachers use a variety of approaches in their classrooms. The data in this study came from only a single week of teaching per teacher and this means that I cannot generalise my findings. I have worked with only two teachers for my study and the two

teachers definitely do not represent the entire teaching population. However, my study did not intend to generalise across all grade 10 mathematics teachers. Rather, it intended to draw on the practices of two teachers to illuminate the challenges of the new curriculum in South Africa.

My study has also shown a limitation of only quantitative counting of classroom occurrences without a simultaneous qualitative analysis. The use of numbers on my table of practices could be interpreted as showing similarities between the two teachers from a quantitative point of view, where in fact there are differences shown by the qualitative analysis. This gives a limitation, therefore, on what this type of data can provide to the reader. But when one looks qualitatively at those quantitative similarities, the differences within these similarities are evident.

5.4 Implications and Recommendations

Mathematics teachers have implemented and continue to implement a range of practices in their various classes. What some teachers may not be aware of is which of the practices they employ in their teaching provide meaning for learners and promote mathematical thinking and reasoning and which of them do not, which of them are traditional and which of them resonate with the new curriculum.

This mixture between traditional and reform practices that I discussed for the two teachers I worked with resonates with the findings I identified in my Honours study. I found myself in the middle of shifts, wherein some of the practices I employed were traditional whilst others were reform-oriented. Since this concurs with my findings for the two teachers in my study, it therefore suggests that there may be other teachers who are faced with similar situations in their classrooms in which there are both elements of traditional and new curriculum practices in their teaching. However, I discussed earlier that it all depends on how the two sets of practices are used to suit whichever situation arises at a particular time. If used strategically, the two sets of practices can develop thinking and reasoning in learners (Brodie, 2005).

Understanding of mathematics is not only restricted to knowledge of concepts and algorithmic procedures. Communication also plays a very important role in the teaching and learning of mathematics (Edwards & Westgate, 1987). An environment that allows learners to communicate about mathematics, if created, can give learners the opportunity to think and reason about what they learn in and/or about mathematics. It is therefore important that learners be given the chance to present their ideas and allowed to convince others in class. This practice may start with some flaws wherein errors and misconceptions may be produced in the process (Nesher, 1987; Brodie, 2005), but given time the practice will become an improved practice in the teaching and learning of mathematics. The two teachers in this study encouraged learners to make contributions in the lessons, but did that in different ways. Whilst Mr. Thekiso would outrightly reject wrong answers, Mr. Ronaldo allowed learners to engage with the wrong answers and used errors produced in those wrong answers to take the lesson forward.

After having seen and described the kinds of practices that two teachers employ in their classrooms, I believe that there is more research needed in investigating more practices from other teachers to help the profession understand which practices contribute to promoting thinking and reasoning. Many teachers, especially in high schools, complain of insufficient training and preparation for the implementation of the new curriculum, and this raises a need for more platforms and avenues to disseminate work obtained through research studies on reform practices. More so that many of these teachers could be coming from a past that denied them opportunities to learn about a range of practices that could empower them to cope with the new curriculum. Despite the training that was offered to teachers in preparation for the new curriculum, many teachers still struggle with implementation. Challenges such as complex language and confusing terminology used in curriculum documents; overcrowding in the classrooms, resulting in insufficient time for implementation; weakness of curriculum on conceptual coherence have been identified (Chisholm et al, 2000). Teachers usually mention these factors among the challenges they face when having to implement practices that resonate with the new curriculum. There are avenues, however, that could be used to illuminate for teachers the practices that they do and can employ in their classes to promote thinking and reasoning.

This study represents one step in this direction. Forums such as professional conferences and seminars are examples of avenues that can assist teachers who grapple with reform practices in education to develop their teaching practices and cope with what the new curriculum requires of them.

There is much to learn from practicing teachers on the work that they do in their classrooms. The practices that teachers employ in their classrooms and the manner in which teachers involve their learners to take up these practices can help improve the learners' thinking and reasoning skills. Some of the practices that teachers employ may come from traditional methods of teaching, but they still remain important practices in reform methods of teaching. I have thus realised through this research study that more research on teachers' practices still need to be explored. Teacher practices in the new curriculum are important and interesting aspects to be explored, and it is for this reason that I plan to continue learning more about such practices. Further research will help me to work with different, practising teachers as well other researchers in influencing the teaching and learning of mathematics in positive and constructive ways, wherein learner participation can be improved in ways that resonate with the new curriculum. Further research on the subject would be more important now as the new curriculum is currently in place in all the grades/phases. Knowing what different teachers do in their classes from foundation phase to FET (Further Education and Training) phase might help improve the standard of teaching and learning if teacher practices are researched further.

References

Adler, J. & Lerman, S. (2003). Getting the description right and making it count: Ethical practice in mathematics education research. In A. Bishop, C. Keitel, J. Kilpatrick and F. Leung. (Eds.) *Second International Handbook of Mathematics Education*. Kluwer Educational Publishers: Dordrecht. Pp. 441-470.

Ball, D.L. (1996). Teacher learning and the mathematics reform: What do we think we know and what do we need to learn? *Phi Delta Kappan*, 77(7), 500-508.

Ball, D.L. & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: knowing and using mathematics. In J. Boaler (Ed.) *Multiple perspectives on mathematics teaching and learning*. Wesport: Ablex.

Bassey, M. (1999). *Case Study Research in Educational Settings*, Buckingham: Open University Press.

Bernstein, B. (1982). On the Classification and Framing of Educational Knowledge. In T. Horton & P. Raggatt (Eds.) *Challenge and change in the curriculum. Milton Keynes: The Open University*. Pp. 157-176.

Boaler (1997). *Experiencing school mathematics: Teaching styles, sex and setting*. Burkingham, UK: Open University Press.

Boaler, J. (1998). Open and closed mathematics: Student experiences and understandings. Journal for Research in Mathematics Education, 29(1), 41-62.

Brodie, K. (2000). Teacher intervention in small-group work. *For the Learning of Mathematics*, 20(1), 9-16.

Brodie, K. (2002). Constraints in learner-centred teaching: a case-study. *Journal of education*, 25:25-160.

Brodie, K. (2004). Working with Learner Contributions: Coding Teacher Responses. In D.E. McDougall & J.A. Ross (Eds.), *Proceedings of the 26th Annual meeting of the North American chapter of the International Group for the Psychology of Mathematics Education*, (Vol. 2, pp. 689-697). Toronto: Ontario Institute of Studies in Education/University of Toronto.

Brodie, K. (2005). *Textures of talking and thinking in secondary mathematics classrooms*. Unpublished PhD Dissertation, Stanford University, (Chapter 1, pp. 21-51).

Brodie, K. (2005). Course notes. University of the Witwatersrand. South Africa.

Brodie, K. (2007). Personal Communication. University of the Witwatersrand. South Africa.

Brodie, K. & Long, C. (2004). Pedagogical responsiveness in mathematics teacher education. In H. Griesel (Ed.), *Curriculum Responsiveness in Higher Education*. Pretoria: South African Universities Vice-Chancellors' Association.

Brown, J.S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher* 18(1), 32-42.

Chazan, D. (2000). *Beyond Formulas in Mathematics Classrooms: Dynamics of the High School Algebra Classroom*. Teachers College Press. New York.

Christiansen, I (1997) When negotiation of meaning is also negotiation of task. Educational Studies in Mathematics, 34, 1-25.

Chrisholm et al (2000). *A South African curriculum for the twenty first century. Report of the review committee on Curriculum 2005*. Pretoria: Department of Education.

Cobb, P. (2000). The importance of a situated view of learning to the design of research and instruction. In J. Boaler (Ed.) *Multiple perspectives on mathematics teaching and learning* (pp.3-76). Westport: Ablex.

Cornbleth, C. (1990). Curriculum in Context. Falmer Press. London. Chapter 2, pp. 12-41.

Davydov, V.V. (1995). The Influence of L.S. Vygotsky on Education: Theory, Research and Practice. *Educational Researcher*, 24(3), 12-21.

Edwards, A.D. & Westgate, D.P.G. (1987). Investigating Classroom Talk. The Falmer Press. London and Philadelphia

Elbers, E. (2003). Classroom Interaction as Reflection: Learning and Teaching Mathematics in a Community of Inquiry. *Educational Studies in Mathematics* 54, 77-97.

Frankel, J. & Wallen, N. (1990). How to design and evaluate research in education. New York: McGraw-Hill.

Hanks, F. (1991). Foreword to Lave, J. & Wenger, E. (1991) *Situated Learning: Legitimate Peripheral Participation*. (pp.13-24). Cambridge, Cambridge University Press.

Hatano, G. (1996). A conception of knowledge acquisition and its implications for mathematics education. In P. Steffe, P. Nesher, P. Cobb, G. Goldin & B. Greer (Eds.), *Theories of mathematical learning* (pp. 197-217). New Jersey: Lawrence Erlbaum.

Hatch, J.A. (2002). Doing qualitative research in educational settings. SUNY. New York. Chapter 4. pp. 147-210.

Heaton, R. (2000). *Teaching mathematics to the new standards: Relearning the dance*. New York: Teachers' College Press.

Hedegaard, M. (1990). The zone of proximal development as basis for instruction. In L. Moll (Ed.), *Vygotsky and Education*. Cambridge: Cambridge University Press.

Kazemi, E. & Stipek, D. (2001). Promoting Conceptual Thinking in Four Upper-Elementary Mathematics Classrooms. *The Elementary School Journal* 102(1). The University of Chicago.

Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding it up: helping children learn mathematics*. Washington, DC: National Academy Press.

Lave, J. (1996) Teaching, as Learning, in Practice. *Mind, culture, and Activity*, 3(3), 149-164. University of California, Berkeley.

Lave, J. & Wenger, E. (1991). Situated Learning: Legitimate Peripheral Participation. New York: Cambridge University Press.

Lampert, M. (1998). Studying teaching as a thinking practice. In J. Greeno & S.G. Goldman (Eds.), Thinking practices (pp. 53-78). Hillsdale. NJ: Erlbaum.

Lampert, M. (2001). *Teaching problems and the problems of teaching*. New Haven: Yale University Press.

Lemke, J. L. (2001). Articulating communities: socio-cultural perspectives on science education. *Journal of Research in Science Teaching*, 38, 296-316.

Mehan, H. (1979). *Learning Lessons: Social organisation in the classroom*. Cambridge, MA: Harvard University Press.

Merriam, S. B. (1992) *Qualitative Research and Case Study Applications in Education*. San Francisco. Jossey-Bass Publishers.

Molefe, N. (2003). Unpublished Honours Research Project. University of the Witwatersrand. South Africa.

Mousley, J.A. (2003) Mathematical and Pedagogical Understanding as Situated Cognition. In N.A. Paterman, B.J. Dougherty & J. Zilliox (Eds.) *Proceedings of the 2003 Joint Meeting of PME and PMENA, Volume 3*. University of Hawaii.

National Department of Education (2003). National Curriculum Statement. South Africa.

Nesher (1987). Towards an Instructional Theory: the Role of Student's Misconceptions. *For the Learning of Mathematics* 7(3), 33-39, FLM Publishing Association, Montreal, Quebec, Canada.

Newman, D., Griffith, P., & Cole, M. (1989). *The construction zone: Working for cognitive change in school*. Cambridge, MA: Cambridge University Press.

Open University Press (1998). *Proof and Reasoning*: A summary.

Opie, C. (2004) *Doing Educational Research – A Guide to First Time Researchers*. London. Sage Publications.

Rand Mathematics Study Panel (2002). *Teaching and Learning Mathematical Practices*.

Schifter, D. (2001). Learning to see the invisible: What skills and knowledge are needed in order to engage with students' mathematical ideas? In T. Wood, B. Scott Nelson & J. Warfield (Eds.), *Beyond Classical Pedagogy: Teaching Elementary Mathematics*. (pp. 109-134). Mahwah, NJ: Lawrence Erlbaum Associates.

Stein, M.K., Grover, B.W., & Henningsen, M. A. (1996). Building student capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. *American Educational Research Journal*, 33(2), 455-488.

Verma, G. K. & Mallick, K. (1999) *Researching Education: Perspectives and Techniques*. London. Falmer Press.

Vygotsky, L.S. (1978). Mind in Society: the development of higher psychological processes. In M. Cole, V. John-Steiner, S. Scribber & E. Souberman (Eds.). Cambridge, M.A.: Harvard University Press.

Wood, T. (1995). An emerging practice of teaching. In P. Cobb & H. Bauersfeld (Eds.), *The emergence of mathematical meanings: Interaction in classroom cultures* (pp. 203-229). Hillsdale, NJ: Lawrence Erlbaum.

Appendix 1: Teachers' consent form

WITS UNIVERSITY SCHOOL OF EDUCATION
27 ST ANDREWS ROAD
PARKTOWN
JOHANNESBURG
2000

Nicholas Molefe
MSc Candidate

Dear _____

CONSENT TO PARTICIPATE IN A STUDY ON MATHEMATICS CLASSROOM PRACTICES

FOR QUESTIONS ABOUT THE STUDY, CONTACT:
Nicholas Molefe
P.O. Box 2452
Krugersdorp
1740

phone: 011-410-6262
fax: 011-953-4788
email: nthatile@mweb.co.za

DESCRIPTION: You are invited to participate in a research study on how mathematics teachers employ practices in the teaching and learning of mathematics. This study forms part of my MSc research at Wits University. I will observe about 5 – 7 of your mathematics lessons in one class. I will take written notes of what I observe and make some video tapes. I will also interview you about how you teach mathematics and video-tape or audiotape our interview.

Unless you request otherwise, your name will be kept completely confidential at all times and in all academic writing about the study. If you give permission, video-clips with you in them may be shown at conferences or in teacher education programmes.

RISKS AND BENEFITS/PAYMENT: There are no foreseeable risks in participating in this study. You will not be paid for participating in the study. Benefits of the project will be a contribution to understandings of mathematics teaching and learning. If you have any concerns about participation, or any questions that you would like to ask, please contact me at any time.

TIME INVOLVEMENT: Classroom observations will take place during class time. I will conduct the interview at a time that is mostly convenient to you. This can be during break, your free period or after school, lasting about 30 minutes.
SUBJECT'S RIGHTS: If you have read this form and have decided to participate in this project, please understand that your participation is voluntary and you have the right to withdraw your consent or discontinue participation at any time without penalty. You have the right to refuse to answer particular questions. Your individual privacy will be maintained in all published and written data resulting from the study.

VIDEO TAPES: If you agree to participate in the study but choose not to allow video clips with you in them to be shown at conferences or teacher education programmes, these tapes will be kept strictly confidential. Once the tapes are no longer needed for research or teaching purposes, they will be destroyed. In most cases, this will be three years after the completion of the study. However, if you give consent, some tapes may be kept for longer. When these tapes are no longer needed, they will be destroyed.

CONSENT

Please complete, sign and return the form attached.

CONSENT FORM

I am willing to participate in the study:

_____ Yes

_____ No

I am willing to be video taped

_____ Yes

_____ No

I give consent for video tapes with me in them resulting from this study to be shown at academic conferences

_____ Yes

_____ No

I give consent for video tapes with me in them resulting from this study to be used for teaching purposes, in teacher education programmes

_____ Yes

_____ No

I give consent for video tapes with me in them to be kept for longer than three years if necessary, for teacher education purposes

_____ Yes

_____ No

The extra copy of this consent form is for you to keep.

Signature: _____ Date: _____

Appendix 2: Parent's consent form

WITS UNIVERSITY SCHOOL OF EDUCATION
ST ANDREWS ROAD
PARKTOWN
JOHANNESBURG
2000

Nicholas Molefe
MSc Candidate

Dear Parent/Learner

CONSENT TO PARTICIPATE IN A STUDY ON MATHEMATICS CLASSROOM PRACTICES

FOR QUESTIONS ABOUT THE STUDY, CONTACT:
Nicholas Molefe
P.O. Box 2452
Krugersdorp
1740

phone: 011-410-6262
fax: 011-953-4788
email: nthatile@mweb.co.za

DESCRIPTION: Your child is invited to participate in a research study on how mathematics teachers employ practices in the teaching and learning of mathematics. This study forms part of my MSc research at Wits University. Your child's mathematics teacher is participating in this study. I will spend about 5 – 7 lessons in your child's mathematics class. I will take written notes of what I observe and make some video tapes. I will interview your child's teacher about how s/he teaches mathematics.

Your child's name will be kept completely confidential at all times and in all academic writing about the study. If you give permission, video-clips with your child in them may be shown at conferences or in teacher education programmes.

RISKS AND BENEFITS/PAYMENT: There are no foreseeable risks in participating in this study. You will not be paid for your child's participation in the study. Benefits of the project will be a contribution to understandings of mathematics teaching and learning. If you have any concerns about your child's participation, or any questions that you would like to ask, please contact me at any time.

TIME INVOLVEMENT: Classroom observations will take place during class time.

SUBJECT'S RIGHTS: If you have read this form and have decided that your child participate in this project, please understand that his/her participation is voluntary and you have the right to withdraw your consent or discontinue your child's participation at any time without penalty. Your child's individual privacy will be maintained in all published and written data resulting from the study.

VIDEO TAPES: If you agree to your child's participation in the study but choose not to allow video clips with him/her in them to be shown at conferences or teacher education programmes, these tapes will be kept strictly confidential. Once the tapes are no longer needed for research or teaching purposes, they will be destroyed. In most cases, this will be three years after the completion of the study. However, if you give consent, some tapes may be kept for longer. When these tapes are no longer needed, they will be destroyed.

CONSENT

Please complete, sign and return the form attached. Please note that if you do not return the form a week before classroom observations commence, it will be assumed that you have consented to your child's participation in the study and s/he be videotaped.

CONSENT FORM

I agree that my child participate in the study:

_____ Yes

_____ No

I agree that my child be video taped

_____ Yes

_____ No

I give consent for video tapes with my child in them resulting from this study to be shown at academic conferences

_____ Yes

_____ No

I give consent for video tapes with my child in them resulting from this study to be used for teaching purposes, in teacher education programmes

_____ Yes

_____ No

I give consent for video tapes with my child in them to be kept for longer than three years if necessary, for teacher education purposes

_____ Yes

_____ No

The extra copy of this consent form is for you to keep.

Learner: _____ Date: _____

Please print your name _____

Parent's signature: _____

Name: _____ Date: _____

Appendix3: Interview Schedule

Name of interviewer: _____

Name of interviewee: _____

Date of interview: _____

Purpose of interview: the interview is an additional method for collecting data. It is based on what I observed during the lessons, as well as on what I think might generally help me to answer my research questions. There is no right or wrong answer, as I only want to understand more about classroom practices.

Interview questions:

1. How would you describe your teaching approach?
2. Why do you teach in this way?
3. What problems, if any, do you encounter with your approach, and how do you deal with those?
4. The way you ask learners questions, how is it of any help to your teaching?
5. The manner in which you handle your learners' responses, what informs it?
6. Are all your learners familiar with your approach of teaching? Do you think they understand your style of teaching?
7. Did you teach differently before? Can you describe that teaching?
8. Can you explain the contributions that your learners usually make in your lessons? Do you think your learners' contributions are of any help towards your lessons? In which way?
9. Have you explicitly taught your learners to make such contributions?
10. One of the things I noticed in your teaching/lessons is …. Can you explain why/why not …
11. Can you use your approach for any class or grade?
12. Is there anything else that we have not discussed that you would like to share with me?