UNIVERSITY OF THE WITWATERSRAND

Title: Teacher questions and interaction patterns in the new and old curriculum: A case study

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DECLARATION

I, Zaheera Jina, declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Education in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination at any other university.

ABSTRACT

The new curriculum in South Africa encourages a shift from the traditional ways of teaching and learning to more interactive approaches. The idea of learning has been redefined, with the focus on how and why children construct meaning. Learning occurs through reasoning and teachers and learners can stimulate reasoning through questions and interaction patterns. Knowledge is constructed in a social context and speech is instrumental in mediating meaning (Vygotsky, 1978). In 2006, the new curriculum was introduced in grade 10, while the old curriculum was still being taught in grade 11. In this study I took this opportunity to explore the differences in teaching supported by the two curricula. A qualitative research methodology and case study method was used to explore the extent to which one teacher in his grade 10 and grade 11 lessons promoted reasoning in his questions and interaction patterns. Data was collected by means of classroom observation with field notes, video recording and a teacher interview. This research shows that the different curricular afford different broad curricular settings (group work and whole class interaction) as an expectation of the new curriculum. However the question types coded for both grades were very similar and did not promote reasoning. Two patterns of interaction emerged within the data: "funneling" and "leading through a method". Both patterns are in IRE/F form but look different from each other. This research adds to other research that indicates that teachers are not clear as to how to generate genuine classroom discussion that promotes reasoning. In the light of the new curriculum, the development of new practices will take time, as change cannot occur immediately. The challenge for teacher education is to understand the changes that teachers are making, in order to develop ways of facilitating the process.

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To my mum, Sharifa for her patience, love and support.

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CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

Social transformation in education is aimed at ensuring that the educational imbalances of the past are redressed. During the apartheid era, education in South Africa experienced a crisis. The crisis was characterized by among other things, major inequalities, high dropout and failure rates, relatively poorly qualified teachers, examination orientedness with a major emphasis on rote-learning and unimaginative teaching methods (Steyn & Wilkinson, 1998). Set against this background, the interim core syllabus (1995) and then outcomes based education (OBE) was chosen to address the crisis. "It (these syllabi) strives to guarantee success for all; devolve ownership by means of decentralized curriculum development; to empower learners in a learner centered ethos; and make schools more accountable and responsible in trying to ensure success", (Steyn & Wilkinson, 1998, pg.203).

The new curriculum encourages a shift from traditional ways of teaching and learning to more interactive approaches. The idea of learning has been reconceptualized, the focus being on how and why children construct meaning. Learner centered approaches are encouraged and teaching is now described as the tool through which meaning is reconstructed, where the learners interpret what they see and hear on the basis of what they already know (Brodie, 2000). In mathematics, the official curriculum focuses on ways in which learners represent and connect mathematical knowledge, the ways in which they understand mathematical ideas and use them in problem solving, because learning with understanding is more powerful than simply memorizing (Kilpatrick, et al. 2001).

In 2006, grade 10 was introduced as the first year of revised teaching and learning in the further education and training (FET) phase. Grade 11 was still being taught using the old curriculum (interim core syllabus). This presented a unique opportunity to understand the extent to which new curriculum ideas actually do reach classrooms, as teachers taught the new further education and training (FET) curriculum in grade 10 and the old (interim core syllabus) curriculum in grade 11. Making use of this opportunity, I have studied one teacher in his grade 10 and grade 11 lessons to see if there were differences in the teacher's questions and interaction patterns in the different curricula. I chose to focus on teacher-learner interaction and questions because, as I will show in the next section, these are key to the visions of the new curriculum.

This study is underpinned by the assumption that what is encouraged in the official curriculum can be very different from the curriculum as it plays out in classrooms (Jansen, 1999; Taylor& Vinjevold, 1999; Taylor, 1999; Todd& Mason, 2005). Understanding teaching processes in terms of the kinds of instructional activities, the way these are sequenced in the classroom, and the way the teacher and learner interact around these, is important in finding ways to improve learners' learning. The aim of this study is therefore to understand teaching processes in more detail in relation to the two official curricula, and the extent to which they promote or inhibit mathematical reasoning.

By analyzing the talk that takes place in the classroom in co-production between teacher and learner, I was able to investigate the new curriculum being put into practice. Current theories of learning argue that learning takes place through reasoning. Teachers and learners can stimulate reasoning through questions and through the ways they interact. Questions and answers are arguably the main way in which teachers and learners communicate (Sullivan & Clarke, 1991). The nature and range of questions used by the teacher in whole class interactive sessions and in small group interactions can affect how mathematics is seen and discussed in the classroom. Questions can support learners' thinking and may focus their attention on asking questions themselves (Watson & Mason, 1998). When teachers ask questions, they could engage the learners to contribute their ideas to the lesson. Whole class interaction can stimulate discussion and promote critical thinking. Interesting patterns of interaction may result. The more specific aim of this study is therefore to investigate whether the teacher's questions and patterns of interaction promote mathematical reasoning in the classroom.

1.2 RESEARCH QUESTIONS

My study is guided by the following research questions:

1. What kinds of questions did the teacher ask in his grade 10 and grade 11 lessons?

2. What are the different patterns of interaction between the teacher and learners in grade 10 and 11?

3. To what extent do the teacher's questions and the different patterns of interaction support mathematical reasoning among learners?

1.3 RATIONALE

This study is a comparison of two different curricula, new and old. A similar study was conducted by Boaler (1997) in England between two schools. The one school (Amber Hill) used traditional "chalk and talk" methods whilst the other school (Phoenix Park) abandoned their textbooks and worked on open-ended projects. Research in South Africa has been conducted on the implementation of Curriculum 2005 in primary schools (Jansen, 1999; Taylor& Vinjevold, 1999; Taylor, 1999; Todd& Mason, 2005) but not much research has been conducted in South Africa on the implementation of the new curriculum in the further education and training phase (FET). I have therefore attempted to adapt Boaler's (1997) study on the differing aspects between the new and old curriculum, as a context for my study.

1.3.1 A DIFFERENT SETTING BUT YET SO SIMILAR

Boaler (1997) approached the study of curriculum change by carrying out comparative studies of two schools: one reform oriented and one traditional, or in our terms the new curriculum compared with the old. Boaler (1997) described a traditional mathematics lesson as being extremely orderly where rule following of procedures dictates the content "transmitted". She questioned the development of learners' understanding using these traditional practices (Boaler, 1997). Conversely she argued, "can we be sure that progressive features of classrooms such as "discovery based learning", mixed ability teaching, independence and freedom really lead to underachievement and lowering of standards as many claim?" (Boaler, 1997, p.1). Boaler (1997) showed that learners from the traditional school believed that mathematical success required memory rather than thought. They had developed a shallow and procedural knowledge that was of limited use in new and demanding situations (Boaler, 1997). The teachers in this system were committed and hardworking but they, like many other mathematics teachers, pursued the belief that, "learners would learn and understand mathematics if they broke questions down and demonstrated procedures in a step by step fashion" (Boaler, 1997, p.39).

In the reform-oriented school, the boundaries between school and the real world were less distinct. The Phoenix Park teachers gave their learners mathematically rich experiences to help them use mathematics. They were concerned with quality rather than quantity of the learners' mathematical experiences and with understanding rather than coverage. The learners were involved in motivating activities and collaborations. They did not regard the mathematics they learnt from being different from the real world. The learners were able to use mathematics in different situations because of their attitudes to the subject. Boaler (1997) showed that different teaching approaches influenced the nature of knowledge that the learners developed. In Phoenix Park as apposed to Amber Hill, the learners had developed powerful mathematical identities and believed they were in control of their learning.

In her work, Boaler makes a sharp distinction between traditional and reform curricula. She deliberately chose schools that epitomized the differences between these. However in general, it is more likely that we will see elements of both traditional and reform teaching practices, particularly in the first years after a new curriculum is introduced (Brodie, 2007, Slominsky & Brodie, 2007))

1.3.2 THE SOUTH AFRICAN CONTEXT

An analysis of the old and new curricula in South Africa reveals similarities and differences between the two. The old syllabus for grade 10 (standard 8), known as the Interim Core Syllabus was introduced in 1995 and its documented change for grade 12 (standard 10) was to be implemented by 1997. This syllabus surfaced in the wake of change (1994) and therefore aimed to work towards the, "reconstruction and development of South African society and the empowerment of its people", (Interim Core Syllabus, Department of Education, 1995). The specific aims of this document range from enabling learners, "to gain mathematical knowledge and proficiency" to facilitating learners in discovering "mathematical concepts and patterns by experimentation, discovery and conjecture", (Interim Core Syllabus, Department of Education, 1995). These aims are very similar to the critical and developmental outcomes set out in the National Curriculum Statement (2003) as they also encouraged a "learner-centered" and "activity-based" approach to education (Interim Core Syllabus, Department of Education, 1995, National Curriculum Statement, Grade 10-12, 2003).

Although the specific aims in the Interim Core Syllabus document are detailed in theory, the document itself failed to provide suggested ways of implementation in its instructional programme but rather focused on the teaching of procedures only. The document listed the mathematics that a learner was required to know at the end of each "standard", for example under the heading "products", the document had listed all the products that the learner needed to know by "inspection". The textbooks complemented the syllabus by explaining the steps to a procedure and giving the learners exercises to practice. It emphasized, "correct mathematics coupled with the practicalities of classroom usage" (Laridon, et al. Classroom Mathematics: Standard 8, 1990).

The new curriculum (National Curriculum Statement) in comparison, demonstrates how the critical and developmental outcomes may be implemented in the use of learning outcomes and assessment standards. Learning, according to the new curriculum documents is progressive in the sense that in grade 10, learners are encouraged to "discover" new knowledge by "investigating, analyzing, describing and representing", and only at grade 12 level would they be required to realize the "formal definition" of concepts (National Curriculum Statement, Grade 10-12, 2003). The emphasis in the National Curriculum Statement lies in the objective of "solving problems" and not in the "mastery" of "isolated skills" (such as factorization).

Thus, it can be said that the aims of both curricula (old and new), judging from their documents, is to produce mathematically proficient learners. However, their notions of mathematical proficiency differs. In the old curriculum it is predominantly about procedural fluency, whereas in the new curriculum it is more about competence in mathematical reasoning and problem solving. The learner should be able to represent and connect pieces of knowledge, understand them deeply and use them in problem solving (National Curriculum Statement, Grade 10-12, 2003). To be able to reason mathematically we need to draw conclusions and make justified statements about what we know in mathematics.

The new curriculum suggests new roles for teachers in that they are now acknowledged as being, "mediators of learning, interpreters and designers of Learning Programmes and materials, leaders, administrators and managers, scholars, researchers and lifelong learners, community members, citizens and pastors, assessors and subject specialists" (National Curriculum Statement, Grade 10-12, 2003). Teachers should adapt their practice to stimulate reasoning (Boaler & Brodie, 2004). Learners cannot develop their thinking unless they are engaged in activities that promote thinking (Van Niekerk & Killen, 2000). Although the old curriculum (interim core syllabus) had somewhat redefined "learning", it had failed to describe the kind of teacher that was envisaged or the route to be taken to make the specific outcomes a reality.

In traditional teaching, teachers tend to avoid discussion with learners and often simplify procedures for them. In doing so they maintain control over the learners but at the same time eliminate enthusiasm and excitement in their classrooms (Nystrand & Gamoran, 1991). It seems as though the teachers follow a script and the purpose of the patterns of interaction is to test learners' knowledge. Sullivan and Clarke (1991) suggest that studying questions enables us to study the connections between teaching and learning in classrooms. They maintain that an improvement in the quality of the questions asked would be a natural and accessible extension of existing teaching practices. Watson and Mason (1998) argue that teachers need to ask questions that promote thought about the structure of the concepts. The questions the teacher asks should generate discussion in the classroom, thus enabling learners to respond to and initiate arguments that will promote reasoning. The learning outcomes in the new curriculum encourage this view by stating that learners need to validate, justify, explain and prove conjectures (National curriculum statement, Grade 10-12, 2003). Thus the relationship between teacher's questions and learners' responses is essential in order to promote mathematical reasoning.

Although the new curriculum provides a good vision, its implementation has been problematic in South Africa. Curriculum reform in other countries has also been problematic. Research into managing and coping with curriculum change has revealed that teachers experience technical, political and cultural issues in managing the process (Hall, 1997). Likewise, in South Africa, outcome based education (OBE), has imposed enormous administrative demands on teachers with regards to planning, assessments and keeping records. Research conducted on instructional innovation in the classroom, in other countries revealed that getting teachers to change is difficult (Duffy & Roehler, 1986; in Brady, 1996). In South Africa, Slominsky and Brodie (2007) argue that it is extremely difficult for teachers to change their practices to become learner-centered. Change is a complex process and teachers cannot be expected to change in short periods of time. Duffy & Roehler, 1986; in (Brady, 1996) argue that teachers are more accepting of change in management than instructional change. In their research Duffy & Roehler, (1986), as described in Brady (1996), showed that teachers experienced difficulty in translating innovation into practice as they encountered various constraints in implementation.

With reference to the research discussed above, I have studied the extent to which a single teacher, teaching both grade 10 and grade 11 mathematics differed in the types of questions asked and interaction patterns which promote mathematical reasoning. I wanted to see if there are differences that could be related to the different curricula. This study can be of benefit to teachers in the further education and training phase (FET) in their approaches to promote reasoning. It could provide teachers with knowledge on what learners need to know in order to become mathematically proficient and how the teacher's questions help shape the patterns of interaction in the lessons. Findings from this research could provide useful data that may serve as a basis for further investigation to explore learners' questions in the classroom. This study will also give insight to the role of different curricula in supporting teacher's questions and learners' responses to promote mathematical reasoning.

1.4 THE REPORT

This report is divided into five chapters. In this chapter (chapter 1), I have provided the background to the study and the research questions that have shaped my analysis. Chapter 2 situates the research in a socio-cultural context. It also develops a conceptual framework for the research by reviewing literature on mathematical reasoning, types of questions asked and patterns of interaction. Chapter 3 provides a motivation for the methodological approach adopted in this study, and a discussion of my methods of data collection. Chapter 4 presents the analysis and interpretation of the research results. In chapter 5, I have attempted to understand the teacher's practices. This chapter also makes suggestions for teachers to be able to promote reasoning in the types of questions asked in whole class interaction.

CHAPTER 2 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, I will discuss the theoretical framework and related literature that has guided my research. The framework is based on Vygotsky's theory of social and psychological development. The framework will assist me in trying to understand how teachers and learners interact in the classroom, the way in which the teacher asks questions that inhibit or promote reasoning and the patterns of interaction that develop. I will also review related literature on questions, interaction patterns and mathematical reasoning.

2.2 VYGOTSKY'S SOCIOCULTURAL THEORY

Vygotsky has developed a theory of psychological development of the individual through social interaction within cultural and historical contexts. One of the most important of these contexts is schooling. Thus his theory provided a useful theoretical framework for the study of teacher and learners using questions in patterns of interaction to promote reasoning.

2.2.1 Psychological tools

Vygotsky differentiated between material tools and psychological tools. He described both as being socially situated. Vygotsky explained that while material tools are aimed at controlling external objects, psychological tools are internally oriented. "Vygotsky made a principal distinction between the lower 'natural' mental processes of perception, attention, memory and will and the 'higher' or cultural psychological functions that appear under the influence of symbolic tools" (Kozulin, 1998, p.14). Psychological tools in their external form are, "symbolic artifacts such as signs, symbols, language, formulae and graphic devices", (Kozulin, 1998, p.14). Kozulin (1998) explains that the foundation of the higher mental functions lies outside the individual in the way he/she interprets the psychological tools and in his/her interaction with others. Thus an individual becomes aware of him/herself through interpersonal relations.

Vygotsky (1987) explained that higher mental functions are an aspect of the learner's cultural development and have their source in collaboration and instruction. He saw instruction as a means of directing attention (Moll, 1990). Vygotsky (1978) focused on the teacher-learner dyad in which speech is instrumental. Speech is seen as an organizer of practices, which helps us to do things to make things happen (Crook, 1994). It is the primary vehicle that learners use to explore conjectures and reason logically. It helps learners develop a more complex and connected understanding of mathematics (Rittenhouse, 1997). Crook (1994) explains that questions posed by teachers serve as an application of speech as they help to direct the course of a lesson and act as a tool for internalisation of thought processes that learner's experience. Internalisation of psychological functions occurs twice, first on a social level between people (interpsychological) and later on an individual level, inside the child (intrapsychological), (Vygotsky, 1978). This means that when the teacher asks questions, interaction is taking place socially in the classroom, the zone of proximal development (ZPD) has been created and speech acts as a tool between teacher and learner. The child might internalise the question, reconstruct it to fit his/her cognitive framework and then respond. The teachers' role is one of mediating between learners' private meanings and socially constructed meanings.

2.2.2 Zone of Proximal development

Vygotsky (1978) proposed that an essential feature of learning is that it creates the Zone of Proximal Development (ZPD); that is:

> "Learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in

his environment and in cooperation with his peers."

(Vygotsky, 1978, p.90)

Vygotsky differentiates these developmental processes in reference to actual and potential developmental levels. He explains that when a child succeeds in tasks independently we are assessing actual development but if a child solves a problem under adult guidance or in collaboration with his peers, the child gains more (potential development). Vygotsky emphasized that the same skill that a child learns through assistance will be mastered independently at a later stage and thus actual development will be eventually achieved and a new stage of potential development will be reached (Vygotsky, 1978).

Moll (1990) argued that the concept of the zone of proximal development (ZPD) may characterize any instructional practice and this can be applied to the analysis of classrooms. He considers the description of the zone usually presented:

1. Establishing a level of difficulty. This level, assumed to be the proximal level, must be challenging for the student but not too difficult.
2. Providing assisted performance. The adult provides guided practice to the child with a clear sense of goal or outcome of the child's performance.
3. Evaluating independent performance. The most logical outcome of the zone of proximal development is the child performing independently.

(Moll, 1990, p.7)

In reference to the above description, Moll (1990) argues that practices in traditional lessons could also be accepted as examples of the zone of proximal development (ZPD). In "traditionally" taught lessons, instruction helps learners develop skills they do not have and the end result is often an individual assessment. Moll (1990) argues that this reduction is hardly what Vygotsky had in mind. Skills form an important part of activities but by focusing on individual skills only, the demand of the task declines.

The teacher plays an important role in developing the zone of proximal development. Through selection and use of mathematical questions that involve conceptual thinking, the teacher can work with the learners to move from initial understanding of concepts to a proficient mastery.

2.2.3 Spontaneous and scientific concepts

Newman and Holzman (1993) explain that Vygotsky saw learning as neither a single process nor as independent processes. Instruction initiates development in the zone of proximal development (ZPD). Instruction is useful when it moves ahead of development. The learner becomes able to engage in developmental activity with conscious awareness rather than spontaneously.

In classroom interaction, the teacher directs the learners' attention to concept formation and procedures in mathematics. Formal instruction has a specialized discourse that helps develop a connected understanding of mathematical relationships (Tharp & Gallimore, 1988). Through formal instruction and in interpreting the classroom discourse, the learners acquire the ability to control consciously these mathematical relationships. Vygotsky (1987) emphasized that spontaneous and scientific concepts are interconnected and interdependent; one cannot exist without the other. Scientific concepts have explicit verbal definitions; learning is made conscious and is taught in the context of academic subjects. Spontaneous concepts are those concepts that the learner learns in the course of his/her daily life. Acquiring spontaneous concepts is not usually conscious and the learner uses these concepts without being aware that there is such a thing as a "concept" (Newman & Holzman, 1993). Vygotsky (1987) explained that it is through the use of everyday concepts that learners make sense of the definition and explanations of scientific concepts. The relationship between spontaneous and scientific concepts is found in the zone of proximal development (ZPD). This relationship is significant to the integration of personal experience and formal knowledge.

Mathematical knowledge consists of both scientific concepts and spontaneous concepts. Learners display the use of mathematical knowledge in spontaneous concepts in their everyday lives. Most school knowledge is scientific knowledge. Scientific concepts develop "from the top down", that is from verbal or mathematical formulae to their "empirical correlates" (Kozulin, 1998). This knowledge in its purely factual or text form never becomes very useful in the learners' everyday life (Hedegaard, 1990). Likewise, Hedegaard (1990) argues that spontaneous concepts do not surface in the classroom in the presence of scientific concepts. Whole class interaction is one way of merging scientific and spontaneous concepts. Vygotsky (1981) claimed that the intellectual skills learners acquire are directly related to how they interact with others in problem solving situations. The teacher can use questions to stimulate this interaction in the zone of proximal development (ZPD). The learners can express themselves and explain their understanding by using everyday concepts and mathematical terminology. By relating scientific concepts to everyday concepts, teaching provides learners with new skills and possibilities for actions.

2.2.4 Interactions

Vygotsky (1981) explained that it is through mediation of others, particularly through mediation of the adult that the learners undertake activities that create their ZPD's. Absolutely everything in the behaviour of the learner emerges from and is rooted in social relations. He also emphasized that social interactions are themselves mediated through speech (Vygotsky, 1981). Therefore the nature of social interactions is central to a zone of proximal development (ZPD) analysis (Moll, 1989).

Language is instrumental in learning about the world. Through social interaction used by the teacher and learner in the course of discussing mathematical concepts, the learner internalizes the instructional setting and the particular discourse. Language is viewed as a vehicle of both interpersonal and intrapersonal psychological functioning (Newman & Holzman, 1993).

Wood (1988) has extended Jerome Bruner's concept of "scaffolding" to describe the teacher's role in helping the learners move from assisted to independent problem solving. Scaffolding as defined by Diaz, Neal & Williams, (in Moll, 1990, p.139), refers to the "gradual withdrawal of adult control and support as a function of children's mastery of a given task". The teacher keeps the learner focused and motivated in completing a task. The teacher may also divide the task into "simpler and more accessible components", thus directing the learners' attention to the significant aspects (Wood, 1988). Wood (1988) developed an approach to the teacher and learner instruction dyad as an interpretation of the zone of proximal development (ZPD).

Wood (1988) defines two principles: "uncertainty" and "contingency". According to Daniels (2001), "uncertainty" makes learning more difficult and "contingency" is a means of assisted performance. Contingent assistance helps to ensure that the learner is supported when in difficulty and at the appropriate level. In a pattern of interaction, when the learner gives a correct answer the teacher reduces the level of control. If a learner makes a mistake, the level of control is raised but this does not mean that levels of uncertainty need to be removed. Uncertainty can stimulate reasoning. The level of support is thus dependent on the learner's progress within the ZPD of interaction. Thus levels of uncertainty and contingency need to be balanced as too much uncertainty may be overwhelming and its removal may mean a shift back to traditional teaching. The teacher's task is to ensure progress. In the learning situation, the learner should realize that the real objective of the interaction is not the task or procedure but the learner's own thinking.

Contrasting the notion of "assisted" versus "unassisted" performance has reflective implications for educational practice. It is in the zone of proximal development (ZPD) that teaching may be defined in terms of learner development (Tharp & Gallimore, 1998). Teaching is good only when it "awakens and rouses to life those functions which are in a stage of maturing, which lies in the zone of proximal development (ZPD)", (Vygotsky, 1956, p.278, in Tharp & Gallimore, 1998). In classroom interaction, if a teacher assists learners by providing structure and asking questions that provoke reasoning, then many learners will begin to internalize this process of approaching a new concept (Tharp & Gallimore, 1988). Teaching can therefore be said, "to occur when assistance is offered at points in the ZPD at which performance requires assistance" (Tharp & Gallimore, 1988, p.181).

"Questions assist performance in ways that lie below the surface" (Tharp & Gallimore, 1988, p.184). Questioning provides a valuable means of assisting performance. When the teacher asks questions, the learners' thought patterns are mentally and verbally activated and the teacher is able to regulate the learner's use of reasoning (Tharp & Gallimore, 1988). Evaluating the learner's response and providing "feedback" on performance is very important to the process (Tharp & Gallimore, 1988). The teacher can guide the learners to think critically. Teaching implies a developmental process. The learner's potential unfolds through mutual interaction of the learner in his/her social environment. The teacher needs to be able to situate the learner in the developmental process. The zone of proximal development (ZPD) can assist in instructional conversational exchanges among teachers and learners. However the teacher needs to be aware that the learners may have something to say beyond the answers expected of the teacher.

In traditional mathematics lessons, learners generally sit silently and follow directions. The teacher explains the mathematics using procedures. There is no interactive teaching taking place as characterized in a zone of proximal development (ZPD). The new curriculum emphasizes an interactive approach in that the teacher creates an interactive setting in which mathematical concepts are tackled in whole classroom discussion.

In this study I have tried to understand how a teacher and his learners interact. My wish was to discover whether the teacher was able to create conversational exchanges given a shift in curriculum. I have shown how a Vygotskian framework provides for an analysis of interaction between learners and the teacher in realization of the goal of promoting mathematical reasoning. In the next section, I will present a review of literature on questions and patterns of interaction and mathematical reasoning.

2.3 QUESTIONS AND PATTERNS OF INTERACTION

Many researchers in mathematics education have raised concerns about effective mathematics teaching. Arguments have been presented in favour of good questions that promote mathematical reasoning (Sullivan & Clarke, 1991; Watson & Mason, 1998; Chazan & Ball, 1999; Kilpatrick et al., 2001; Boaler & Brodie, 2004). Boaler & Brodie (2004) argue that, "the act of asking a good question is cognitively demanding, requires considerable content knowledge and necessitates that teachers know their learners well", (Boaler & Brodie, p.1, 2004).

Watson & Mason (1998) believe that questions such as "How did you…?" and "what if…?" are typical questions intended to provoke learners into becoming critical thinkers. They further explain that questions like "give an example of…?", "Is it true that…?" reflect mathematical thinking. Sullivan & Clarke (1991), in their book on the importance of good questioning, differentiate between lower order and higher order questions. Supported by detailed studies of classrooms they concluded that more effective teachers used open questions and that asking more higher order questions enhances learning. However, other categories of questions have been developed which give more nuanced descriptions. These will be discussed later in the report.

Traditionally, as described by Rittenhouse (1997), teachers have been viewed as sole classroom authorities about mathematics. They decided which mathematical content was to be learned, they demonstrated how to solve problems and they evaluated the learner's responses. Learners in contrast listened to their teachers explain how to do procedures and they worked individually to solve problems. As a result teachers were generally the only persons in the room who actually talked about mathematics.

The new curriculum in the FET phase presents a learner-centered approach which encourages that learners should be able to make decisions using critical and creative thinking (National curriculum statement, grade 10 – 12, 2003). Communication serves as a tool in the new curriculum to facilitate learning. Teachers are encouraged to make their lessons more learner-centered by motivating learners to contribute their ideas to the lesson. However, even when learners do contribute, many question and answer exchanges in the classroom are not seen to be helpful in developing the learner's mathematical thinking (Brodie, 2007). Classroom research has identified a number of different interaction patterns. These patterns are products formed through social interaction between teacher and learners (Nystrand & Gamoran, 1991).

Nystrand & Gamoran (1991) and other researchers (e.g. Brodie, 2004; 2007) build on a key structure of classroom discourse – the IRE/F identified by Mehan (1979) and Sinclair & Coulthard (1973, in Brodie, 2007). Brodie (2004) describes the IRE/F as follows: "a teacher makes an initiation move, a learner responds, a teacher provides feedback or evaluates the learner's response and then moves on to a new initiation. Mehan (1979) calls this basic structure a sequence". Brodie also argues that, because teachers tend to ask questions to which they already know the answer (Edward & Mercer, 1987), they tend to "funnel" the learner's responses towards the answers they want (Bauersfeld, 1988). Bauersfeld (1988) defines funneling as being a process of fragmenting tasks into smaller pieces. The teacher changes the status of a question by simplifying it for the learners. The teacher has an answer in mind and depending on the learner's responses; the teacher would most likely present the solution him/herself.

Researchers, (Sullivan & Clarke, 1991; Watson & Mason, 1998; Chazan & Ball, 1999; Kilpatrick et al., 2001; Boaler & Brodie, 2004, Brodie,2007), have shown that teachers often begin with more exploratory, higher order questions, but teachers and learners often work together to narrow the questions and funnel towards answers (Bauersfeld, 1988). Teachers often funnel when learners don't respond to the questions asked. Rittenhouse (1997) explains that learners may not respond in classroom interaction if they do not have the tools to do so. Learners may not know how to enter a mathematics conversation or how to express their reasoning. The style of argument used in reasoning mathematically may be very different from the other kinds of talk learners are expected to engage in.

Rittenhouse (1997) argues that the new curriculum does not create change on its own. She explains that while selection of appropriate tasks and collaborative techniques are important, they are not enough to encourage the learners to talk mathematically. She uses Gee's notion of discourse to explain that in order for learners to participate in classroom interaction they need to learn a mathematical discourse. This discourse is made up of the ways of thinking, acting and speaking mathematically (Gee, 1991 in Rittenhouse, 1991). The teacher's role of fostering mathematical discourse amongst learners is one of helping them to comprehend and use the discourse to deepen their understanding of mathematics (Rittenhouse, 1991).

With reference back to the notion of assisted performance and the zone of proximal development (ZPD), assisted performance may be initiated by means of higher order questions. The development of any performance in the individual represents a changing relationship between the intrapsychological and interpsychological being. Gradually over time, the learner requires less assistance and is able to work independently. The progress through the ZPD is a gradual process which the teacher needs to "scaffold" (Tharp & Gallimore, 1988)

Watson and Mason (1998) believe that teachers need to pay more attention to their questioning as many questions that are intended to encourage thinking may be too general or sophisticated to answer. The teacher has to process many forms of information in the moment. This means that the teacher needs to listen to the response and then connect the learner's answer to the discussion through a question that would be interesting enough to stimulate discussion (Lampert, 2001) and specific enough to assist the learner to respond. Davis (1997) has termed this form of listening as "hermeneutic listening" as it regards the teacher as an active participant, engaging with the learners in critical discussion of mathematics.

Many teachers believe that if they ask questions and if the learners respond, than the learners are participating in the lesson (Brodie, 2007). Teachers often ask questions of which they know the answer to. Teachers need to listen to the learners' responses in order to provide appropriate feedback. Quite often, the teachers are listening for a particular answer and this prevents discussion. Davis (1997) has termed this manner of attending, “evaluative listening”. The motivation of this listening “appears to be evaluating the correctness of the contribution by judging it against a preconceived standard”, (Davis, 1997, p.359). Davis (1997) differentiates between “listening to” and “listening for”. He terms “listening to” to be interpretive listening and hermeneutic listening. By using interpretive listening, the teacher is assessing the learners and at the same time gaining access to the sense being made (Davis, 1997). Hermeneutic listening demands that the teacher “interrogate” his/her thought process in “attentiveness to the historical and contextual situation of one’s actions and interactions” (Davis, 1997, p.370). The teacher needs to become an active participant in the classroom. Thus to maximise learner-centred teaching, all members of the classroom community need to listen to each other.

Boaler and Brodie (2004) have explained in their paper that they coded teacher’s questions in order to capture the finer differences in comparative classroom observation. They developed nine categories of teacher question types, which differentiated between higher and lower cognitive demand type questions. By coding the teacher’s questions they intended to illuminate the relationship between curriculum and teaching (Boaler & Brodie, 2004). Their findings suggested that the questions asked in the classrooms were closely related to the different curricula used (Boaler & Brodie, 2004). For my purpose, it was important to code individual questions in order to capture the important issue of sequencing in patterns of interaction. I also wanted to determine whether these questions and patterns of interaction produce and reflect mathematical reasoning.

2.4 MATHEMATICAL REASONING

As a goal of instruction Kilpatrick et al. (2001) discuss that mathematical proficiency provides a way to think about mathematics learning in that it encompasses the key features of knowing and doing mathematics. Mathematical proficiency implies expertise in handling mathematical ideas. Learners who are mathematically proficient, “understand concepts, are fluent in performing operations, exercise a selection of strategic knowledge, reason clearly and maintain a positive outlook towards mathematics", (Kilpatrick, et al. 2001). These learners are also able to use the five strands of mathematical proficiency in an integrated manner, so that each strand reinforces the others. The five strands of mathematical proficiency are:

1 Conceptual understanding - comprehension of mathematical concepts, operations and relations;
2 Procedural fluency- skill in carrying out procedures flexibly, accurately, efficiently and appropriately;
3 Strategic competence- ability to formulate, represent, and solve mathematical problems;
4 Adaptive reasoning- capacity for logical thought, reflection, explanation and justification; and
5 Productive disposition- habitual inclination to see mathematics as sensible, coupled with a belief in diligence and one's own efficacy.

(Kilpatrick et al. 2001)

The five strands constitute the knowledge, skills, abilities and beliefs that all mathematics learners should be able to master. Kilpatrick et al. (2001) explained that these strands are intertwined in the development of proficiency in mathematics. The first two strands are what schools traditionally emphasized. The learner's conceptual understanding and procedural fluency are tightly connected, in that the learners will only use methods fluently and flexibly if they understand them. Mathematical reasoning according to Brodie (2000) includes formulating, testing and justifying conjectures, which can be done in all grades and in all topics. In developing mathematically proficient learners, teachers have to give learners opportunities to reason. Brodie (2000) argues that teachers should stimulate learners into thinking and justifying conjectures. Teachers can also present opportunities for the learners to discuss, evaluate and mutually agree on ideas. Teachers need to be able to hear and see expressions of learners' mathematical ideas and they need to be able to respond in appropriate ways. As discussed previously in this section, from a Vygotskian perspective, a major role of schooling is to create social zones of proximal development and social contexts for mastery of and conscious awareness in the use of cultural tools (Moll, 1990). It is through this mastery that learners will acquire the capacity for mathematical reasoning.

Kilpatrick et al. (2001) further argue that teachers are unlikely to provide an adequate explanation of concepts if they do not understand them themselves. Teachers will be unable to engage their learners in productive conversations about multiple ways to solve problems if they themselves can only solve it in a single way. Teachers with a weak conceptual knowledge of mathematics tend to demonstrate procedures to learners and then give them opportunities to practice it. The knowledge, beliefs, discussions and actions of both teachers and learners affect what is taught and ultimately learned. The learners vary in their interpretations and their responses affect what becomes the enacted lesson. The teacher's attention and responses to the learners further shape the course of instruction. Thus instruction takes place in a social context and the pedagogical challenge for teachers is to manage instruction so as to develop mathematical proficiency (Kilpatrick, et al. 2001).

2.5 CONCLUSION

In this chapter, I have developed a theoretical and analytic framework for understanding teaching and learning in mathematics classrooms. The zone of proximal development (ZPD) forms the foundation for my analysis of teacher/learner interaction in classroom instruction. In my discussion I have argued that knowledge and skills cannot be internalised in the form transmitted. The teacher needs to mediate and assist learners to express meaning in ways that will enable them to reason mathematically. "Teacher questions provide an important methodological lens for understanding these relationships" (Boaler & Brodie, 2004, p.1). I have looked at how teacher's questions create different interaction patterns. In so doing, I have also argued that teachers need to manage discussion so as to promote reasoning. In the next chapter, I discuss the research process that will be used to answer my research questions.

CHAPTER 3 DATA COLLECTION AND METHODOLOGY

3.1 INTRODUCTION

In the previous chapter, I discussed the theoretical and analytical framework that informed my research. In this chapter I will map out the route I took in planning and collecting information concerning the teacher's questions in the classroom and the extent to which they promoted mathematical reasoning. I have discovered that conducting this kind of research is not easy, as some teachers don't ask any questions while others ask many questions that do not promote reasoning. A careful selection of methodology and methods in such research therefore became an important issue for the validity and reliability of the findings.

3.2 METHODOLOGY

As this study sought to identify the types of questions and patterns of interaction, as well as how they influence mathematical reasoning, a qualitative research methodology seemed suitable as it, "seeks to understand how phenomena are produced through activities of particular people in particular settings" (Silverman, 1998, p.102). The aim of this study was to recognize the social world of the classroom and how the teacher's questions and patterns of interaction promote mathematical reasoning. Since knowledge is acquired socially, I considered that close observation of classroom interaction between the teacher and learners would help me understand the aspects of the classroom atmosphere that prove challenging for the teacher when asking questions or generating discussion.

The research approach that I chose fitted into a case study method. A case study has been described as,

> "… A real situation, with real people in an environment often familiar to
> the researcher. Its aim then is to provide a picture of a certain feature of

> social behaviour or activity in a particular setting and the factors
> affecting this situation."
>
> (Opie, 2004, p.74)

Using the case study research method, I studied the interactions of learner responses and teacher's questions in a unique location. The experiences were rooted within a context (Merriam, 1998) and this method allowed me to focus on a specific situation and to explore the various interactive processes at work within that situation (Verma & Mallick, 1999).

3.3 DATA COLLECTION

The concern of this study was to investigate the types of questions asked by the teacher and the emerging patterns of interaction, and whether these promoted mathematical reasoning. In order to access these areas of enquiry, I used three methods of data collection: classroom observation with field notes, video recording and a teacher interview. I observed and videotaped 5 lessons in grade 10 and 5 lessons in grade 11. I conducted one post interview after having observed all the lessons. The interview was taped and later transcribed. I used the classroom observations and videos to categorize questions asked and to note differences in the different curricula (grade 10 and grade 11). I used the interview to understand the teacher's perspectives on his practice.

Maxwell (1996) argues that observations and interviews can provide a more complete and accurate account than either can alone. Observations can be distinguished from interviews in two ways: observations take place in natural setting instead of a location designated for the purpose of interviewing and observational data represents a first hand account of events rather than an interpretation as in an interview (Merriam, 1998). Observation, "often enables you to draw inferences about someone's meaning and perspective that you couldn't obtain by relying exclusively on interview data", (Maxwell, 1996, p.76). Interviewing can be a valuable way of gaining a description of actions and events (Maxwell, 1996), as well as the participant's perspectives.

Thus emphasis on observation only, gives a description of classroom interaction (the researchers perspective) whilst emphasis on the interview would mainly provide the perspective of the teacher. A combination of the two gives a more complete picture of the classroom activities and interaction. The use of different sources and different methods helped to produce results that are more comprehensible than would be the case with fewer methods and sources.

3.3.1 Classroom observations with field notes

"Observation is the best technique to use when an activity, event or situation can be observed first hand, when a fresh perspective is desired, or when participants are not able or willing to discuss the topic under study", (Merriam, 1998, p.96). I filmed and observed while a colleague wrote detailed notes. The field notes provide a description of the lesson being observed.

3.3.2 Videotaping

"The visual image has occupied a salient place in the discipline of social anthropology and sociology for considerable time", (Hitchcock& Hughes, 1995, p.308). It allows the researcher to see things, which s/he would not have otherwise seen through live observations. Video recording as a visual source provides a rich source of data about what is going on in the classroom. It gives the researcher a chance to review classroom action during analysis.

I had used an observation schedule developed by Boaler & Brodie (2004) to analyze the questions asked by the teacher from the video. I had anticipated that observation schedules recorded in real time (having a simple grid and ticking every time a question was asked) would not suit this research study as teacher and learners questions in interaction may play out at a very fast pace and coding these questions may be problematic. Questions also need to be seen in the context of subsequent interaction. I am also interested in the patterns of interaction which surface in the lessons and I was aware that an analysis of the videos would assist me in describing these.

There are a number of problems associated with the use of video recording. It is seen as being problematic as it is time-consuming and troublesome. It brings with it technical problems with focusing and ensuring good sound quality. The video recorder as explained by Hitchcock and Hughes (1995) does not capture reality accurately and it may capture one reality as what we see is filtered through our own experiences, backgrounds and positions in the world. In my case, to minimize disruption, the video recording was taken from the side of the class so that both the teacher and the learners could be captured when talking. Video recording can also be seen as a problem as it entails pointing the camera at someone and thus making it clear that he or she is directly being observed.

3.3.3 Teacher Interviews

I conducted the teacher interviews after having analyzed the videos. I had observed interesting patterns of interaction in the data and I hoped that the teacher would in his description reveal insight into his practice. Before the interview I explained to the teacher that I was not trying to assess his knowledge. I told him that I wanted him to think back to his lessons and to discuss these with the aim of describing his interaction with the learners. I did this because I was aware that the teacher's responses are likely to be influenced by his view of the researcher and in doing so he may fabricate his answers (Bassey, 1995).

The interview was semi-structured. The interview schedule (appendix 2) consisted of fourteen questions. Using the questions as a platform, I probed more deeply into the responses given as well as what I had observed in the lessons. The interview was tape recorded and later transcribed. Bassey (1995) explains that the advantage of recording for the researcher is that she can attend to the direction rather than the detail of the interview and then listen intently afterwards.

In the interview, I asked about issues that were pertinent to particular teaching moments, or the learners' responses (or lack thereof). For example, after asking, "What do you experience? What goes through your mind when a learner gives an incorrect answer or does not answer?" I would then point to a specific incident that I had observed. This encouraged the teacher to reflect more deeply on his lessons.

3.4 THE TEACHER

In order to conduct this study, I needed to find a single teacher teaching both grade 10 and grade 11 mathematics. This search was difficult as there are very few teachers who teach these grades in combination. I consulted many schools in Soweto but the principals of most schools were not keen to participate in this research. I consulted the mathematics facilitator for the district closest to my home, who gave me the names of three teachers who taught these grades in combination. I observed the first teacher only to discover that she did not ask any questions in her lessons. The second teacher was willing to be a subject but refused permission of having a video-camera in her classroom, and the third teacher was willing to participate in this study and in conversation suggested that he knew about the pedagogical changes suggested by the new curriculum. (refer to chapter 4 for an in depth analysis). I therefore chose to work with this teacher.

My research shares a context to that of the research conducted by Mr. Stephen Modau who is also a Master's student. Since we were only able to find one teacher teaching both grade 10 and grade 11 mathematics that was willing to participate in the study, we consulted our supervisor and decided to research different aspects of the same teacher's practices. Mr. Modau's interest lay in the choice and implementation of mathematical tasks in the different curricula and mine in the questions and interactions around the tasks. Our supervisor agreed that our work would complement each other's, and as it turned out the fact that we could have extensive discussions with each other about the same teacher's practices both enriched the research and added to its validity.

The teacher had been teaching both grade 10 and grade 11 mathematics for over nine years. He had recognized qualifications (BSc in mathematics, Higher diploma in Education (HDE), Advanced Certificate in Education (ACE), and Honours in Management) and had attended the NCS training in 2005, which focused on the implementation of the new curriculum for grade 10 in 2006. The training took place over five days and focused on different aspects of the Further Education and Training (FET) band. These focus areas included: the development of the National Curriculum Statement, mediation of subject learning outcomes and assessment standards, teaching and learning; and assessment and planning and design of learning programmes (National Curriculum Statement: Participant's Manual, C.L.A.S.S. consulting, 2005). These focus areas were presented by a group facilitator and teachers worked on activities in groups. The teacher also attended a follow-up training in 2006, which supplemented the 2005 training and focused on its realization at grade 11 level. The teacher in this study was aware of the changes in the curriculum and he portrayed a positive outlook regarding its implementation (to be shown in chapter 4). He taught the same content (functions) to both grades but was clearly using different classroom activities and tasks in the two grades. I have elaborated more on these differences in chapter 4. The teacher was thus suitable for our study as he had experience in teaching the old curriculum and had undergone training in preparation for teaching the new curriculum.

3.5 THE SCHOOL

The school is situated in a township on the periphery of the larger Johannesburg area – the West Rand. There are 1800 learners at the school with a staff of 45 teachers. The teacher/learner ratio is 1:50. The school does not have adequate classrooms due to the increasing number of learners enrolling at the school. In recent years, the schools matric results have improved and their average pass rate was 70% in 2005. The majority of learners are from poor families, most of whom cannot afford to purchase basic mathematical tools, for example calculators, and this results in many learners not been able to complete tasks, or taking longer than the rest, since they have to borrow calculators from others.

The study was conducted in two mathematics classes. There were 40 learners in grade 10 and 9 learners in grade 11. The class size in the grade 11 class was very different from the norm and was highly unusual for a township school. These learners were repeating grade 11 on a standard grade level and were part of a class of 43 learners who shared the same subjects except mathematics. When the 9 learners attended mathematics, the rest of the class attended travel and tourism. Due to the unavailability of classrooms, the teacher did not have access to a permanent classroom and therefore, in moving around, time was wasted. The differences between the class sizes in the two grades will be dealt with in relation to the analysis in chapter 4.

3.6 DATA ANALYSIS

"Data analysis is a systematic search for meaning", (Hatch, 2002, p.148). It means organizing and interrogating the data, deriving patterns, discovering relationships and making interpretations (Hitchcock & Hughes, 1995; Hatch, 2002). I began my analysis by transcribing all the lessons. I then coded all the questions asked by the teacher using the codes developed by Boaler & Brodie (2004). Nine categories of teacher's questions were used from Boaler and Brodie's (2004) analysis of United States schools

Question Type	**Description**
1. Gathering information leading students through a method	Requires immediate answer Rehearses known facts/procedures Enables students to state facts/procedures
2. Inserting terminology	Once ideas are under discussion, enables correct mathematical language to be used to talk about them
3. Exploring mathematical meanings and/or relationships	Points to underlying mathematical relationships and meanings. Makes links between mathematical ideas and representations
4. Probing, getting students to explain their reasoning	Asks students to articulate, elaborate or clarify ideas
5. Generating discussion	Solicits contributions from other members of class
6. Linking and applying	Points to relationships among mathematical ideas and mathematics and other areas of study/life

7. Extending thinking	Extends the situation under discussion to other situations where similar ideas maybe used
8. Orienting and focusing	Helps students to focus on key elements or aspects of the situation in order to enable problem-solving
9. Establishing context	Talk about issues outside of math in order to enable links to be made with mathematics

Table 2: Categories of teacher's questions (Boaler & Brodie, 2004)

I chose this analytical framework because it resonated with the literature on questions in chapter 2, in that it demonstrated the idea that good questions promote reasoning as well as describe the relationship between curriculum and teaching (Boaler & Brodie, 2004). This analytical framework also links well with Kilpatrick et al's five strands of mathematical proficiency.

The first strand is conceptual understanding and is described by Kilpatrick, et al. (2001, p.118), as being an "integrated and functional grasp of mathematical ideas". Learners with this understanding know more than isolated facts and methods. They display meaning and use of methods when representing solutions. Questions which aim to explore or promote conceptual understanding would usually be of types 3, 4 or 5 in the framework. Teachers could explore mathematical meanings and relationships by asking questions that probe the learners, extend their thinking, orient and focus learners thought processes and generate discussion. These question types are not evaluative of the learner's knowledge; they do not close down into the IRE/F but rather allow the learners to express themselves.

Procedural fluency refers to knowledge and skill in performing procedures. It may appear that in interaction, this strand is singled out in relation to the other strands, as in explaining the steps to a procedure; the teacher may follow the IRE/F. This does not mean that the teacher is necessarily promoting procedural fluency as the strands are interlinked and the learner would need to have a conceptual understanding to be procedurally fluent. It may also seem as though the teacher may ask more question type 1's in working through a procedure thus making it seem as though this question type is less useful than the others. However, Boaler and Brodie (2004, p.6) have shown in their study that the reform-oriented teachers asked between 60 and 75% of type 1 questions, but at the same time they also asked a greater range of questions, including more of the other types than the traditional teachers. So there is no assumption that certain question types are of less or more value than others, as depending on the context the teacher could effectively use question type 1's, in conjunction with other questions, to elicit mathematical reasoning.

Strategic competence can be linked to question types 3 to 9, as it refers to the learner's ability to formulate mathematical problems, represent them and solve them. To represent the problem correctly, learners need to first understand the situation and these question types help direct the learners to do this. Adaptive reasoning refers to the capacity to "think logically about the relationships amongst concepts and situations", (Kilpatrick, et al. 2001). Teachers can develop adaptive reasoning by establishing a context thus making links to mathematics. Teachers can extend thinking by asking questions types 2, 4, 6, 7, 8 and 9 that could help the learners to articulate, elaborate or clarify their ideas. Learners who have developed a productive disposition see mathematics as worthwhile and are confident in their knowledge and ability to solve problems. Question types 7, 8 and 9 promote the learner's ability to maintain productive dispositions to this subject.

While it is important to link particular question types to the various strands, what I have shown above is that there is not a 1-1 correspondence between the two frameworks. It is also important to note, as I argued above, that individual questions do not stand on their own, they need to be considered in relation to questions that came before and after and to the rest of the classroom interaction.

I will now explain some decisions that I made about coding my data. Maxwell says that in qualitative research,

> "the goal of coding is not to produce counts of things, but is to fracture the data and rearrange it into categories that facilitate the comparison of data within and between those categories and that aids in the development of theoretical concepts"
>
> (Maxwell, 1996, p.78)

In coding the questions I had to make decisions about what counted as a question. I chose to include utterances that had both the form and function of questions and which were mathematical (Boaler & Brodie, 2004). At times, within a context, a question may be a question in form but may not function as a question (for example, "would you like to come and show us your idea"). Similarly, "prompts" (Watson & Mason, 1998), refer to statements that expect a response, even if there is no question mark (for example, "sine of 90º is…"). A prompt will function as a question even though it does not have the form of a question. In a set of repeated questions, I only coded the initial question. In the example below, there were three questions in the turn, but I coded it as only one:

> Teacher: And what is OB? What is OB? From O to B, how many units is that?

When a teacher asked a question and repeated it after a pause or after a learner had responded, I coded and counted both questions. This differs from Boaler & Brodie's (2004) coding, as they coded repeated questions as such but excluded them from the final count.

I then categorized the question types in each grade and compared the two grades. In doing this, certain patterns emerged. I analysed to see whether the teacher's questions supported mathematical reasoning. I transcribed the interview and observed the lessons again. I adapted and extended the analysis where possible and supported the claims made using transcribed examples from the data. The learners' replies were important in coding the teacher's questions, as at times what seemed to be a higher order question was a lower order question depending on the dialogue that contextualized it.

3.7 VALIDITY AND RELIABILITY

Validity and reliability of research are crucial in all social research regardless of disciplines and methods employed (Sherman & Webb, 1988). This means that collected data must be accurate and authentic and analysis must ensure an adequate account of reality. Validity ensures that a method measures what it is supposed to measure. One of the ways that a researcher may inhibit validity in interpretation is if the researcher comes with his/her own preconceived ideas of what s/he might find. It is important that these ideas however, do not override the meaning and perspectives being studied. I have tried to avoid this by giving evidence with transcripts of the teacher and learners' utterances where appropriate. During the interview I also tried to probe the teacher's viewpoints by referring to particular incidents in his teaching that helped to reveal his perspectives. I have tried to be as explicit as possible about my own assumptions and shifts in thinking when doing the analysis.

Reliability is the extent to which a method gives consistent results over a range of settings. Reliability is difficult to achieve, as the case study is qualitative. As the researcher, I became one of the instruments. The triangulation from my data sources and the careful recording of each step of the research process and all decision points provided a means for others to assess the reliability of my study. This assessment was done with my research group, which is made up of my supervisor, a doctoral student, Mr. Modau and another master's student. Many of my interpretations were supported and I was prompted to reconsider some, thus adding both to the reliability and validity of the account.

3.8 ETHICAL ISSUES

I have abided by the university's code of ethics for researchers on human subjects. The universities ethics committee approved the study: Protocol 20006ECE06. I waited for approval from the Gauteng Department of Education (GDE) before collecting data. Parents and legal guardians of learners were requested to sign consent forms. These forms informed the participants of the study and assured them that they could withdraw at any point in the research. All the parents and learners provided consent. The teacher and principal agreed to the terms of data collection.

In addition to the required ethics procedures, it is important for the researcher to act ethically at all times. Bassey (1995) explains that observation of the classroom has a sense of formality in that the participants know that they are being watched. This contributes to the power relations between the researcher and participants. We (Mr. Modau and I) tried to mitigate these power relations by explaining to the teacher and the learners prior to data collection that we would not be assessing them but would be observing their classroom practices in order to try to understand them better. We asked them to behave as naturally as possible and we also tried to be as sensitive as possible as to when our presence might create difficulties for the teacher and the learners.

3.9 LIMITATIONS

The research cannot be generalized for a number of reasons. Firstly, the comparison between grade 10 and 11 will only be evident for the present. The new curriculum is currently being implemented in grade 11 and research and teacher education programmes may improve the situation in future for schools. The number of lessons observed were also too few to be able to give a generalized view of all situations. The study is qualitative and therefore the results are not generalisable in the statistical sense. However it is hoped that the findings will illuminate issues of teacher and curriculum change for teachers, teacher educators and researchers.

3.10 CONCLUSION

In this chapter, I described the process that enabled the research: the choice of methods, and instruments to conduct the study. I have given a description of the context in which the study took place. Issues of validity, reliability and ethics were also discussed. The next section describes the findings and analyses of the mathematics teacher's questions and interaction patterns in the new and old curricula.

CHAPTER 4 DATA ANALYSIS: QUESTIONS AND INTERACTION PATTERNS

4.1 INTRODUCTION

In this chapter I present the analysis of questions asked in the classroom by classifying them according to Boaler and Brodie's (2004) framework. I will show how the more cognitive type questions lowered in demand because of the kind of answers given by the learners. I have also identified two sequences of interaction in the data. I will discuss these sequences as they emerged and so illuminate their development in the grades in which they occurred. Throughout the chapter I will compare what is happening in the two grades using the field notes, interview and the lesson transcripts.

4.2 CATEGORIES OF CLASSROOM ACTIVITIES

My first coding scheme is a broad one and differentiates two categories of classroom activities. This aimed to describe how teachers spent their time in the grade 10 lessons in comparison to the grade 11 lessons. The categories that I have chosen are whole class interaction and group/individual work. In both the grade 10 and grade 11 classes the whole class interaction is mainly question related. I have not differentiated between the group work and individual work in the grades.

Characteristics/Description	Grade 10 (New curriculum)	Grade 11 (old curriculum)
Total time of lessons	184min.	176min.
No. of questions	143	297
Whole class interaction	88min. 48%	168min. 95%
Group work/individual	86min. 52%	7min 5%

Table 1: General characteristics of lessons

Table 1 reveals that the teacher managed the time in the two classrooms differently. The learners worked in groups for much more of the time in the grade 10 class, which is encouraged by the new curriculum. In the grade 10 lessons, 52% of the time was spent in-group work and the remaining 48% of the time the class was involved in whole class interaction. These figures are starkly different to the 5% of group work and 95% of whole class interaction in grade 11. These findings show that different curricula give rise to different broad curricular settings as an expectation of the new curriculum.

While providing valuable information on the differences of the same teacher teaching the new and old curriculum, this coding exercise did not capture the similarities or reasons for the differences. My detailed observations and qualitative analysis shows that given the difference in curricula and broad curricula settings, the teacher generated very similar classroom environments. In order to capture these similarities, I have coded all the questions asked by the teacher in the lessons.

4.3 TASK ANALYSIS

A brief analysis of the tasks implemented in the lessons is needed to contextualize my analysis. Modau and Brodie (2008) showed that the teacher designed tasks on "functions" for both grades but implemented them differently in the lessons. In the grade 10 lessons, the teacher gave the learners new curriculum tasks as well as enough time to implement these tasks in groups as described in 4.2 above. Modau and Brodie (2008) categorized the tasks according to Stein et al's (1996) framework and showed that in the grade 10 lessons the learners were mostly engaged in tasks that involved "procedures with connections to meaning". The findings of Modau's research show that even though the learners in the new curriculum were given higher-level tasks, the cognitive demands of the tasks declined during classroom interaction (Modau & Brodie, 2008). In the grade 11 lessons however, the teacher selected lower level tasks, requiring mainly "procedures without connection" (Stein et al, 1996) and the tasks remained at that level at implementation. The analysis revealed that the teacher had a clear intention on how he wanted to implement the tasks but during practice he was unable to implement them as intended (Modau & Brodie, 2008).

4.4 CODING OF QUESTIONS ASKED IN THE CLASSROOM

I have used an analysis schedule developed by Boaler and Brodie (2004) as described earlier in chapter 3. In coding the teacher's questions, decisions had to be made about what counts as a question (Boaler & Brodie, 2004). I chose to include utterances that had both the form and function of questions and which were mathematical (Boaler & Brodie, 2004). I coded repeated questions as a single question. My results indicate that only question types 1; 2; 3 and 4 were present and therefore I will only refer to these categories in my analysis. Table 3 shows the result from the coding of the five grades 10 and five grade 11 lessons. Only whole class interactions were coded.

Question Types	Frequency: Grade 10	Frequency: Grade 11
1	125 87%	267 90%
2	1 1%	5 2%
3	14 10%	20 6%
4	3 2%	5 2%
Totals	143 100%	297 100%

Table 3: Grade 10 and Grade 11 coding of questions

The findings in this table are stark. Most of the questions asked by the teacher in both grades were of type 1. The teacher rehearsed known facts and procedures by leading the learners through a method. Only 14% of the questions posed in grade 10 were classified as probing, terminology related or targeting concepts. This is similar to the 11% asked in grade 11. The teacher presented the grade 10 learners with tasks that were of a higher cognitive demand than the tasks given to the grade 11 learners but at implementation, the demands of the tasks in both grades declined (Modau & Brodie, 2008). It was interesting to see, given the change in curriculum and tasks given that the types of questions asked by the teacher were very similar in both the grade 10 and grade 11 lessons. More time was spent in whole class interaction in the grade 11 lessons, in comparison to the time spent in the grade 10 lessons. Thus the number of questions analyzed in the grade 11 lessons was more than in the grade 10 lessons. The teacher did ask questions when the learners worked in groups but group work is a different pedagogical form and in order to limit the scope of this study, I chose to focus on whole class interaction only.

4.5 LOWERING THE DEMANDS OF QUESTIONS

A qualitative analysis of when and how different questions were asked in the grade 10 and grade 11 lessons will illuminate how question types 3 and 4 were lowered in demand by the kinds of responses given by the learners. The following extract comes from a lesson in the grade 10 class. The teacher asked the learners to complete function tables and compare the relationship between the two variables across rows (see Appendix 2.2 for the task). The value of y is multiplicatively related to the value of x. The learners drew the graph of $y=x^2$ by firstly completing a table. They squared numbers to find the corresponding y value in each ordered pair. The lesson was designed to engage the learners in the conceptual and procedural development of the topic. After the learners had completed the task in groups, the teacher tried to summarize what had been learnt by asking questions.

Turn No.	Speaker	Dialogue	Code	Description
17	Teacher	Right umm, one point two, **what happens to the graph as the x values continue to increase?** Now in this graph *(teacher points to the board)* if your x values increase what happens to your y values? **What happens to the graph?**	3	Makes links between mathematical ideas and representations
18	Learners	It expands		
19	Teacher	It expands, are you sure? Let's check it.	1	Requires an immediate answer
20	Teacher	When x is one, your y is one, when x is two, your y is four, when x is one, your y is one *(teacher writes on the board)* when x is two your y is four. When x is three your y is?	1	Requires an immediate answer
21	Learners	Nine		
22	Teacher	Nine, when your x is four, your y is?	1	Leading learners to an answer
23	Learners	Sixteen		
24	Teacher	**What do you mean it expands? What do you mean it expands? How does it expand?**	3	Makes links between mathematical ideas and representations

25	Learners	*(Silent)*		
26	Teacher	How does it expand? How does it expand? *[Teacher writes on the board* $(1)^2$; $(2)^2$; $(3)^2$*]* Look at this how does it expand then?	1	Leading learners to an answer
27	Learners	*(Silent)*		

Grade 10, lesson 2

In the extract above, the teacher asks the learners (turn 17) what happens to the graph as the x values increase. I coded this question as a type 3 as it attempted to explore mathematical relationships. The learners replied (turn 18) that the graph expands. The teacher did not probe the learners on their response. The type 3 questions had reduced in demand by the answer given by the learners and by the teachers not probing further. The teacher attempted to validate the learner's answer by providing an explanation in turn 20. The learners spoke only in response to type 1 questions (turn 21 and 23). They did not answer when the second type 3 question was asked (turn 24). The teacher's actions and utterances transmitted the message that there is only one correct answer that he could authorize. None of his actions transmitted the meaning that the question types (3 and 4) are open to multiple solutions in that the learners can bring their understanding to the discussion. The teacher was aware of his actions as in the interview he stated that, "… maybe it's because of my style of teaching that he is probably going to give us the answer anyway…" The teacher's questions did not encourage the learners to think deeply in response to the questions asked.

The extract below comes from the grade 11 lessons. The teacher asks the learners questions regarding the graph of y= ½ tanx and y=3cosx (see Appendix 3.1 for the task). The learners were required to draw both graphs on the same set of axes indicating the turning points and asymptotes.

Turn no.	**Speaker**	**Dialogue**	**Code**	**Description**
1.	Teacher	I want us to check this point, two hundred and twenty five degrees times half, tan of that?	1	Requires an immediate answer
2.	Learners	Negative two		

3.	Teacher	**Will you only have one asymptote?**	3	Make links between mathematical ideas and representation
4.	Learners	*(Silent)*		
5.	Teacher	How will you sketch this graph? How does it look like?	1	Rehearses known facts and procedures
6.	Learners	*(Inaudible)*		
7.	Teacher	*(Reads from the worksheet)* Show your intercepts and turning points?		
8.	Teacher	**Where do you have your turning points? If you look at your cos graph, where will your turning points be?**	3	Make links between mathematical ideas and representation
9.	Learners	*(Inaudible)*		
10.	Teacher	What is the x value there?	1	Requires immediate answer
11.	Learners	Hundred and eighty degrees		
12.	Teacher	And the y value?	1	Requires immediate answer
13.	Learners	Negative three		
14.	Teacher	**Are you able to tell me what the intercept there should be?**	3	Makes links between mathematical ideas and representations
15.	Learners	*(Silent)*		

In turn 3 the teacher asks the learners whether the graph of y= ½ tanx will have only one asymptote. I have classified this question as a type 3 question as the teacher tried to make links between mathematical ideas and representations. The learners did not answer. The teacher did not rephrase the question or offer an explanation. It appeared as though he had expected the learners to make inferences at the end of the lesson from the illustration drawn on the board. The teacher then simplified the next question from the worksheet by asking the learners to show him the turning points of the cosine graph. The learner's answer could not be heard. The teacher did not ask the learner to repeat what he had said. He rather simplified the question and directed the learners to finding the ordered pair at the turning point.

The teacher did not pick up on a learner's response or challenge his thinking. It's very seldom that the learners provided an explanation to a question asked. It seems as though the teacher experienced the dilemma of reconciling the goal of respecting the learner's thinking with the goal of helping them acquire "conventional" knowledge and procedures (Cazden, 2001). Thus, in the co-production of knowledge between teacher and learner, question types 2, 3 and 4 reduced in demand.

4.6 PATTERNS OF INTERACTION

In analyzing the types of questions asked, I have identified the presence of the initiation-response-feedback/evaluation (IRE/F) structure (Sinclair & Coulthard, 1973; Mehan, 1979). The teacher asks a question, the learners respond and the teacher evaluates the learner's response and moves on to the next question. "Often the feedback/evaluation and subsequent initiation moves are combined into one turn and sometimes the feedback evaluation is absent or implicit" (Brodie, 2007). Brodie (2007) argues that the IRE/F structure is a "form" that can be used in different ways and achieve different kinds of mathematical thinking in the classroom.

I have identified two patterns of interaction within the data: "funneling" and "leading through a method". Bauersfeld (1988) defines funneling as being a process of fragmenting tasks into smaller pieces. The teacher asks a higher order question and then learners don't respond or answer incorrectly, so the teacher repeats the question, or changes the status of the question by simplifying it for the learners. This sequence is repeated until the teacher actually presents the solution to the learners.

"Leading through a method" is a drill sequence in that the teacher initiates a question, the learner's respond and the teacher initiates again. The teacher asks questions based on the procedure that he is teaching. This sequence can also be described as a "gap fill" procedure as the learners respond immediately. All the questions asked are of question type 1 as the teacher leads the learners through a method by rehearsing known facts and procedures. The "leading through a method" sequence is predominantly in the grade 11 lessons and in the grade 10 lessons, both "leading through a method" and funneling are prevalent.

The following "leading through a method" sequence comes from the grade 11 classroom. The teacher is leading the learners through the method of drawing the sine graph. The teacher asked only type 1 questions and the learners used their calculators to find the plotting points on the graph. The teacher used the chalkboard as a resource.

Turn no.	Speaker	Dialogue
29	Teacher	What is half of ninety degrees?
30	Learners	Forty five degrees
31	Teacher	What is sine of forty five degrees?
32	Learners	Zero comma seven
33	Teacher	And sine ninety degrees?
34	Learners	One
35	Teacher	What is between ninety degrees and one hundred and eighty degrees?
36	Learner	One hundred and thirty five degrees
37	Teacher	What is sine one hundred and thirty five degrees?
38	Learner	Zero comma seven
39	Teacher	Sine one hundred and eighty degrees?
40	Learner	Zero
41	Teacher	Now without using your calculator, what is sine two hundred and twenty five degrees? What is the value of sine two hundred and twenty five degrees?
42	Learner	Zero
43	Teacher	No
44	Learner	Ninety degrees
45	Teacher	No
46	Teacher	Just check it, what is sine two hundred and twenty five degrees??
47	Learner	Negative zero comma seven

Grade 11 Lesson 1

In the above sequence it is evident that the learners are working with the teacher. The teacher requires an immediate answer and the learners respond to the type 1 questions that the teacher asks. Thus the teacher rehearses known facts and procedures by leading the learners through a method. Even though there is one type 3 question (turn 41), the learners get it wrong and the teacher keeps saying "no" until they get it right, thus lowering a higher order question as discussed previously. This sequence is common in both the grade 10 and grade 11 lessons.

The following is an example of a "funneling" sequence that occurred only in the grade 10 lessons. In the grade 10 classroom the learners sat in groups and worked on tasks. The teacher used the new curriculum tasks of "self discovery" to enable the learners to investigate the effects of the parameters "a" and "q" on the sine graph (see Appendix 2.1 for the task). In the extract below the teacher held a discussion based on the task that the learners had worked on in groups. This activity is activity 1 on the worksheet. This activity expected the learners to draw the graph of y=2sinx+1 and compare it to y=sinx in order to make generalizations about the effect of the parameters "a" and "q" on the graph in the extract below. I have described the "funneling pattern" following how Bauersfeld (1988) described it.

Turn No.	**Speaker**	**Dialogue**	**Description**
36.	Teacher	What is the effect of *q* what does *q* do to the graph?	The teacher opened the episode
37	Learners	*(Inaudible chatter)*	The expected reaction failed to come as the learners muttered inaudibly.
38.	Teacher	But you have just told me that the graph has moved by one unit up, so what does *q* do to the graph?	The teacher repeated the question.
39.	Learners	Cuts y axis at 1	The learners give an incomplete answer
40.	Teacher	Cuts the y-axis at one, partially you correct but something is missing. We are now making a general statement. What is the effect of this *q*? What does *q* do to the graph when you sketch the graph?	The teacher repeated the question twice. He gives them a hint indicating that something was missing from the answer given.
41.	Learners	*(Silent)*	The learners did not answer and this has a confusing effect (his confusion is evident in his next question) on the teacher
42.	Teacher	Are you failing to see? *(Teacher points at 1 in the equation y=2sinx+1)* What is this?	The teacher got frustrated when the learners did not answer. He asked, "Are you failing to see?" He did not wait for an answer but focused the learners attention on the place value of q in the equations y=2sinx+1 and y=asinx+q. He used the "leading through a method" sequence to achieve the recognition of the effect of q on the graph. He had thus reduced the demand of the question and simplified it.
43.	Learners	One	
44.	Teacher	*(Points at q in the standard equation)* What is this?	
45.	Learners	q	
46.	Teacher	Look at the graph of y=2sinx+1, where does it start?	
47.	Learners	One	
48.	Teacher	How many units has it shifted from zero?	

49.	Learners	Two, one	
50.	Teacher	So what does *q* do to the graph?	The teacher posed the question again.
51.	Learners	Moves the graph two units *(inaudible)*	The learners did not give the expected answer.
52.	Teacher	It lifts the graph, *q* lifts the graph.	The teacher provided the answer without providing a conceptual explanation.
53.	Learners	Yes sir	

In the above extract, the teacher initiates the sequence with a type 3 question. He then funneled for the expected answer when the learners did not respond correctly. When explaining the concept, he changed over to the "leading through a method" sequence. The transcript (turn 42 - turn 49) indicates that the learners respond correctly to the type 1 questions asked in the "leading through a method" sequence. The teacher believes that when he asked these questions and when the learners responded, this meant that they were participating in the lesson. When asked in the interview about whether he considered questions to be important, the teacher replied that,

> "It is very important that you should have questions, you know on an ongoing basis because if you ask them the questions you also gain their understanding in terms of the concepts that you teaching them. So on a number of times; you must engage these learners by asking them questions just to get feedback from them."

In reflection on the transcript (turn 42-turn50), it would appear as though the learners have understood the effect of the parameter "q" on the graph, but from the answer given in turn 51, we can see that this is not the case. This move from the funneling sequence to the "leading through a method" sequence was evident in all of the grade 10 lessons. It occurred at those times when the learners did not respond to a repeated question. The teacher reacted by shifting the sequence. He expressed his emotions at these moments. In the interview, he said,

> "Ja ja, at that time when they don't answer. I get frustrated. I always pose my questions in such a way that they become easy to understand but I get frustrated when the solution doesn't come and on a number of times I will repeat the question, phase it differently but when the solution doesn't come, I end up giving out the answer and I know I shouldn't

> be doing that, you know because if I give out the answer a lot then these learners don't actually do anything."

The teacher emphasized the frustration that he experienced when the learners did not respond. He found himself under pressure and shifted to a "leading through a method" sequence. Using this sequence, he redefined the questions asked. He broke the problems down for the learners, as he believed that this would help them learn mathematics. In the interview, he stated that,

> "I need to know where am I taking these learners to, unlike you know in the traditional way of teaching, we could just teach anything but now you must be aware of where and what you want them to achieve at the end of the day".

It seems as though the teacher changed over to the "leading through a method" sequence, as he believed that the learners would experience failure if he did not structure the work for them. It's as if the participants follow hidden regulations that they are not aware of (Bauersfeld, 1988). The teacher shifts between sequences as a mechanism to assist him in dealing with his frustrations in the moment.

The extract below is situated as a continuation to the lesson described above. The extract, however differs from the first one in that the teacher did not shift between sequences. He used the funnel sequence only (T56-T67) and then he explained the effect of the parameter "a" in turn 68.

Turn no.	**Speaker**	**Dialogue**	**Description**
54.	Teacher	What about *a*? What does *a* do to the graph? Lets look at these two graphs what does *a* do to the graph? The first one is just y=sinx, the second graph you put the value of y which is the green one. So let's compare these two graphs. What does *a* do to the graph? How does it influence the graph?	A new sequence began and the teacher asks the learners to explain the effect of "a" on the graph. He did not allow the learners to answer. The teacher repeated the question three times and did not allow for any "wait time" in-between. As described earlier the time per question was very short and the questions played out at a very fast pace.

55.	Learners	*(Silent)*	
56.	Teacher	Are these two graphs the same?	The teacher asked them a question so that the learners can make inferences from the drawings on the board and answer.
57.	Learners	No sir	The learners replied that the graphs are not the same.
58.	Teacher	What makes them to be different?	The teacher asked the learners to give him the differences from what they see from the drawings.
59.	Learners	*(Silent)*	The learners did not reply.
60.	Teacher	Is it because one is green and one is white?	The teacher added humour to the question so as to ease the tension.
61.	Learners	No… *(Laughter)*	
62.	Teacher	What makes them to be different?	The teacher posed the question again.
63.	Learners	I think the green graph moves two units upward	A learner replied. The teacher did not press for conceptual understanding. He posed type one questions. The learners were able to describe the shift but there was no indication of whether they understood the effect of the parameter "a" on the graph.
64.	Teacher	Moves two units upward from?	
65.	Learners	From zero	
66.	Teacher	From zero, okay, how many units downwards?	
67	Learners	Two units	
68.	Teacher	So in short the *a* gives you the amplitude of the graph. Amplitude is simply how high that is your maximum point and how low the graph can go. So if you look at this value your amplitude is two that means your graph must go two units up or two units down. That is what *a* does to your graph. And your *q* only gives it a shift.	The teacher had funneled down to an explanation.
69.	Teacher	Your *q* is positive, what do you think will happen to the graph? Your q is positive, what do you think will happen will it go up or down?	The teacher enabled the learners to state facts previously learnt by asking type one questions. He had given the learners alternatives to choose from. He did not ask for a further explanation of their answers.
70.	Learners	Up	
71.	Teacher	What do you think will happen if your *q* is negative?	
72.	Learners	Go down	
73.	Teacher	It will move down, you sure?	
74.	Learners	Yes sir	
75.	Teacher	Now who can tell me what is the influence of *a* on the graph? What is the influence of *a* on the graph? What does *a* do to the graph? Joyce?	The teacher tried to recap on the conceptual understanding of the parameter "a" on the graph.
76.	Learners	*(Laughter)*	
77.	Teacher	But you get the sense of what is happening here	He did not press the learners for reasoning and he did not explain.

There are two important issues that are evident in the above extract. The first concern argues that the teacher did not promote a conceptual understanding of the task in whole class interaction (Modau & Brodie, 2008). The learners worked on the task in groups and then came together to discuss the concepts in whole class discussion. In reference to the extract above, it is evident that in whole class discussion, the teacher did not make a connection between what the learners communicated in their groups to the central aim of the task. The teacher initiated the sequence with a question type 3 in turn 54, the learners did not respond and the teacher funneled his questions down to an explanation in turn 68.

The second issue relates to the teacher's view of learning outcome 2 (functions and algebra) in relation to his practice. Grade 10 is the first year of progression in the further education and training (FET) phase. "The content and context of each grade will show progression from simple to complex", (National Curriculum Statement, Grade 10-12, 2003, p. 3). Teaching functions in grade 10 has shifted from being content and procedurally based. The emphasis is a more intuitive understanding rather than a formal definition of the concept. In turn 68, the teacher focused on explaining definitions of the terms associated with the parameters "a" and "q". In this turn he stated that, "*a* gives you the amplitude of the graph. Amplitude is simply how high that is your maximum point and how low the graph can go". In reference to the National Curriculum Statement (NCS) (2003), however, the learners are only required to understand the "formal" definition of a function and its properties in the grade 12 year. So although he is working with the new curriculum tasks, he may still be working with his long-term understanding of content from the old curriculum.

In reference to the transcript, it appears as though the teacher is not sure how to interpret the mathematical knowledge in this learning outcome. In the interview, he stated that:

> "Ja, like I said I think you see the teaching of mathematics requires you as a teacher to be impartial and let the learners understand the procedures on how the outcomes should be achieved because if you only give them answers without explaining to them how things must be done then I don't think that's actually fair because at the end of the day as a

> teacher you only want them to understand how concepts are applied. I think that is why I'm always explaining to them why things must be done."

From the teacher's explanation and the transcript, it can be argued that the teacher is still focused on teaching rules and procedures. He believes that by explaining to the learners, he is "making" them "understand" how concepts are applied. Although the teacher's interaction patterns differed in the two grades, it seemed as though his knowledge relations were similar for both grades. He explained the effects of the parameters "a" and "q" (turn 68), by using the formal definition of a function the way it had been traditionally taught in the old curriculum. After explaining in turn 68, he repeats the question in turn 75 and the learners are still not able to respond.

4.7 MATHEMATICAL PROFICIENCY AND MATHEMATICAL REASONING

In analyzing the extent to which the teacher's questions and interaction patterns promoted reasoning, I had to consider that the five strands of mathematical proficiency are intertwined and "must work together if learners are to learn successfully", (Kilpatrick, et al. 2001, pp. 133).

The question types coded were similar for both grades. The teacher asked more question type 1's, than question types, 2, 3 and 4 in his lessons. In whole class interaction between teacher and learner, the higher order questions lowered in demand based on the kinds of responses given by the learners. The learners co-produced a lack of mathematical reasoning with the teacher.

In the grade 10 lessons, the teacher used both the funneling pattern and "leading through a method" pattern. The learners worked on cognitively demanding tasks in groups. They were required to investigate, analyse, describe and represent a wide range of functions to determine the effects of the parameters "a" and "q" on the graphs. A significant indicator of conceptual understanding is being able to, "represent mathematical situations in different ways and knowing how different representations can be useful for different purposes", (Kilpatrick, et al. 2001, pp.119). The tasks were aimed at achieving conceptual understanding (Modau & Brodie, 2008). In whole class interaction, however the learners were unable to respond to question types 2, 3 and 4, which were intended to support, conceptual understanding.

The task (analysed in section 4.5), required that the learners perform procedures of substituting values to illustrate the function graph of $y=x^2$. The teacher probably expected that the learners were procedurally fluent in substitution but in the whole class interaction, they were unable to explain why the graph of $y=x^2$ expands if the x values continue to increase (see Appendix 2.2 for task 1.3). In the extract (turn 20) the teacher explained the procedure of substitution of the x values to find the corresponding y values and was trying to describe to the learners how the graph expands as the x values increase. Even though he re-explained the procedure in turn 26, the learners were unable to develop a conceptual understanding.

Kilpatrick et al. (2001) argue that learners are able to present reasoning ability when three conditions are met: "They have a sufficient knowledge base, the task is understandable and motivating and the context is familiar and motivating", (Kilpatrick et al. 2001, pp.130). The tasks used in these lessons were cognitively demanding and motivating and the learners built on this knowledge base as they worked through the tasks (Modau & Brodie, 2008). The learners however were unable to justify and explain their ideas in whole class interaction. It is possible that they could have perceived the context as being uncomfortable. It cannot be assumed that they did not reason adaptively as learners often understand before they can verbalize that understanding (Kilpatrick et al. 2001). The teacher was unable to promote discussion and therefore there was no evidence of the learners reasoning in whole class discussion.

In general, the teacher's questions and interaction patterns did not promote reasoning. In the grade 10 lessons, the teacher initiated sequences using higher order questions. It appeared as though he wanted the learners to reason and communicate their ideas. In most cases the learners did not respond so the teacher funneled his questions to an explanation. The grade 10 learners have developed mathematical proficiency in a very uneven way. They are most proficient in procedural fluency and less proficient in the other strands.

In the grade 11 lessons the teacher used only the "leading through a method" interaction pattern. The lessons were traditionally taught and the teacher explained procedures. The grade 11 learners in this class were repeating the grade but their conceptual understanding of mathematical ideas had not been developed as the teacher still explained isolated facts and procedures. Without sufficient procedural fluency the learners had difficulty understanding mathematical ideas. This was evident in the lesson described previously (pg.42), where the teacher leads the learners through the method of drawing the sine graph. The attention that they devoted to evaluating trigonometric expressions using a calculator prevented them from realizing from the sketch on the board, that the answer to sine 225º is the negative value of sine 45º. The learners had been previously taught the procedure of drawing the sine graph without understanding it conceptually; therefore they could not use the graph as a tool to develop their understanding.

The learners did not think logically about the relationships among concepts and situations. With reference to the task in Appendix 3.2, the extract below shows that the learners did not reason adaptively.

No. of turn	**Speaker**	**Dialogue**
1.	Teacher	Which equation represents a parabola
2.	Learners	*(Silent)*
3.	Teacher	You've got two equations. Baswa?
4.	Baswa	Two
5.	Teacher	Which equation? Which equation?
6.	Learner	Y is equal to two x squared minus three x minus two
7.	Teacher	And which is the equation of your straight line?
8.	Learner	Y plus x is equal to zero

9.	Teacher	*(Teacher explains that A and B are x intercepts on the graph)* So which equation are you going to use? So which equation are you going to use to find the x intercepts at A
10.	Learners	*(Silent)*
11.	Teacher	Which graph passes through A? Which graph passes through A?
12.	Learners	*(Silent)*
13.	Teacher	Do you see point A?
14.	Learners	Yes sir
15.	Teacher	So which graph passes through point A?
16.	Learner	The parabola

In the above extract, the teacher asked only type 1 questions using the "leading through a method" pattern. The learners did not make links between questions asked and interpretation from a sketch. The learners did not identify the linear function and parabola graphs in the sketch (turn 1–turn 8). It appears as though the learners have not as yet developed a sufficient knowledge base and they have not understood the procedure previously taught. "Understanding procedures make learning skills easier and less prone to forgetting", (Kilpatrick, et al. 2001).

Using the traditional curriculum and methods of instruction, the teacher's questions and patterns of interaction did not stimulate mathematical proficiency amongst the grade 11 learners. The learners, however, were able to identify characteristics of graphs and hence use the applicable characteristics to sketch function graphs.

This analysis suggests that the teacher attempted to facilitate the new curriculum by using different tasks. The tasks used in the grade 10 lessons were of a higher cognitive demand than the tasks used in the grade 11 lessons (Modau & Brodie, 2008). However, the teacher's questions and interaction patterns lowered the task demands and did not manage to promote the full range of mathematics reasoning.

4.8 THE TEACHER'S VIEWS

An analysis of the teacher's interview responses revealed that the teacher intended to teach differently in the "new" curriculum. When asked about his implementation of the new curriculum the teacher explained that he needed to be aware of the policy changes in his practice as it, "helps you as a teacher to start preparing and taking those learners from where they are to where we want to have them as a country…" He also responded that these changes meant that he needed to be "innovative" in terms of his teaching.

In an earlier discussion on pg.45 of this chapter the teacher explained that he redefined the questions that he posed to the learners because within the new curriculum he needs to know "where he is taking the learners to" unlike in the "traditional way of teaching", he could just teach "anything". He explained that he now needs to be aware of where and what he wants the learners to achieve at the end of the day".

From these responses it can be seen that the teacher understands the new and old curriculum in dichotomous ways. The teacher had realized the prescriptions set out by the new curriculum and was aware of its implementation in grade 10 but he did not see that the implementation of the new curriculum would achieve a better understanding irrespective of whether it was practiced in grade 10 or in grade 11. When asked about his teaching in the grade 11 lessons, he explained that his teaching differed from the grade 10 lessons because he could assume that the grade 11 learners were taught the procedures during the previous year when they were in grade 10 and therefore they have the "background" knowledge of these concepts. The analysis of his whole class interaction revealed otherwise, as the grade 11 learners were not able to reflect upon their past knowledge, as they did not have a conceptual understanding of it. This view has been elaborated on in section 4.7 of this chapter. Thus it may be seen that the teacher revealed certain "misconceptions" regarding the purpose and goals of change, in that the new curriculum is applicable for the documented year of implementation only and that it suggests that learners do not need to know procedures. This view was in fact contradicted in his teaching because he did teach procedures in Grade 10, although arguably not as well as in Grade 11.

Teaching within the Further Education and Training phase is now progressive along the grades. This means that learners are only required to generate function graphs by means of “point-by-point plotting” in grades 10 and 11, and only in grade 12 do they work with the formal definition of these graphs. The analysis in section 4.6 of this chapter reveals that the teacher was still focused on teaching rules and procedures in grade 10. In the interview the teacher stated that by explaining to the learners, he is “making” them “understand” how concepts are applied. The analysis in section 4.6 also revealed that although the teacher is working with new curriculum tasks, he may still be working with his long-term understanding of content from the old curriculum.

In relation to the Further Education and Training (FET) workshop that the teacher attended (refer to chapter 3.4), it is evident that the teacher only engaged in working with learning outcomes and assessment standards in policy documents without being encouraged to reflect on its true purpose. There was too much of an emphasis on the “correct” use of the policy documents. From the analysis of the teacher’s interaction patterns in both grades, it seems as though certain underlying messages were conveyed in these training sessions and therefore these training sessions need to be addressed with a conscious view of purpose. The fact that there were only nine learners in the grade 11 class may be seen as a limitation to the study but also contributes to its findings as it suggests that the ability to achieve the kind of interaction that the curriculum requires does not depend in a large way on class size, but also on how the teacher sees such interaction and its promotion of the goals of the curriculum.

4.9 CONCLUSION

In this chapter I have attempted to understand the teacher’s practice. This analysis suggests that mathematics teaching differed in the two grades. The grade 11 lessons were predominantly whole-class oriented whereas the grade 10 lessons centered on group-work and whole class interaction. However the question types coded in whole class interaction, which the study was limited to, were similar for both grades and were mainly lower order (type 1). Even higher order questions lowered in demand in the interaction between teacher and learners.

In the grade 10 lessons the teacher attempted to keep with the style of the new curriculum by using cognitively demanding tasks, group work and initiating whole class discussion with higher order questions. The teacher did not encourage the learners to communicate the ideas discussed in their groups in whole class interaction. It seemed as though group work and class discussion were separate mediums, which the teacher struggled to bring together. He asked type 2, 3 and 4 questions and the learners did not respond or gave incorrect answers, he did not refer them back to their group work or previous knowledge rather he funneled to an explanation or shifted to the "leading through a method" pattern. In the new curriculum, functions are introduced in grade 10 where learners are required to substitute values and plot points to investigate the effects of the parameters "a" and "q" on the various function graphs rather than through formal definitions. The teacher in whole class interaction tried to explain the effects of the parameters theoretically by focusing on the "definition" of the function. It appears as though the teacher still maintains his old curriculum ideas of what constitutes "mathematical knowledge" as well as his implementation of tasks in practice.

In the grade 11 lessons the teacher's questions emphasized the "leading through a method" sequence. The learners responded and were able to repeat the procedures taught. However, this pattern of interaction did not promote reasoning. In the next chapter, I will present a discussion of the findings of the research as well as implications and suggested recommendations.

CHAPTER 5 CONCLUSION

5.1 INTRODUCTION

This chapter draws conclusions from the findings of the study indicating an explanation for the teacher’s practice as well as possible recommendations.

5.2 DISCUSSION OF FINDINGS

This study has explored the extent to which a single teacher teaching both grade 10 and grade 11 mathematics was able to promote reasoning through the types of questions asked and the interaction patterns developed. I have responded to the following questions in my analysis:

1. What kinds of questions did the teacher ask in his grade 10 and grade 11 lessons?

2. What are the different patterns of interaction between the teacher and learners in grade 10 and 11?

3. To what extent do the teacher’s questions and the different patterns of interaction support mathematical reasoning among learners?

This study has shown that the teacher employed two categories of classroom activities in both grades (whole class interaction and group/individual work). In the grade 10 lessons, 52% of the time was spent in group work and the remaining 48% of the time the class was involved in whole class interaction. These figures are starkly different to the 5% of group work and 95% of whole class interaction in grade 11. The execution of the grade 10 lessons differed to the grade 11 lessons. In the grade 10 lessons the learners worked on tasks in groups and then came together as a class to discuss the answers. In the grade 11 lessons, the teacher taught the procedure and then the learners worked on their own to complete the task. Modau and Brodie (2008) showed that the teacher used tasks of a higher cognitive demand in the grade 10 lessons and more “old curriculum”, lower cognitively demanding tasks in the grade 11 lessons. These differences in tasks were expected as a result of the change in curriculum. The question types coded and interaction patterns however revealed interesting similarities, between the teaching in the grades and the two curricula.

The question types coded in both grades were similar and did not promote reasoning. Most of the questions asked in both grades were of question type 1. In the grade 10 lessons the teacher often initiated a sequence with a higher order question, but reduced the demands with funneling. In the grade 11 lessons the teacher asked question type 2, 3 or 4 in the context of explaining a procedure. The learners did not respond or responded incorrectly to these questions (question type 2, 3 or 4). The teacher did not probe further, nor did he wait for an answer. He was aware of the importance of asking such questions but was unable to elicit a response from the learners and when they answered he did not probe them for justification. Because of this, interesting patterns of interaction emerged within the data.

I identified two patterns of interaction within the IRE/F sequence and labeled them as “funneling” and ‘leading through a method”. In the grade 10 lessons, the teacher used both patterns of interaction whereas he used only the “leading through a method” sequence in grade 11. Using the “funneling” pattern, the teacher tried to get an expected answer from the learners by reducing the cognitive demands of the questions asked. The sequence ended with the teacher explaining the procedure. When using the “leading through a method” pattern, the teacher asked mainly question type 1’s in working through a method, occasionally inserting a higher order question.

Neither pattern promotes reasoning but in using the latter pattern, the teacher was able to ascertain that the learners could perform the steps to a procedure. The previous chapter indicated that it was difficult for the teacher to change his practices to become more learner-centered. Learner centered practices go beyond the traditional view of teaching and learning to that which encourages participation and critical reflection. In the light of the new curriculum, “teachers can become so preoccupied with executing new roles that they may lose sight or control of other elements”, (Slominsky & Brodie, 2007). The teacher was aware of the developments in curriculum but was only able to execute some changes in his practice. He allowed the grade 10 learners to engage in groups in exploratory investigative activities but he did not manage to elicit their reasoning in whole class discussion. He did not encourage the learners to communicate their group work findings but was rather concerned with explaining mathematical rules clearly as he believed that then only would the learners gain access to them. Instead of banishing this as bad teaching, I needed to understand his practice as a first step in changing practice. These findings have implications for teaching and learning mathematics in the new curriculum.

5.3 IMPLICATIONS

My research adds to other research that indicates that many teachers do not manage to generate classroom discussion. Teachers are able to implement group work and are able to choose cognitive tasks (Modau and Brodie, 2008), but they struggle to promote mathematical reasoning in whole class interaction.

My research is set in a context of a globalizing country, a country that is similar and yet very different to other countries. South Africa has a unique, historical foundation and education is contextual. Change in this country was necessary and unlike with other countries, change, including the new curriculum in South Africa has been welcomed. Change, however takes time and within this process a lot may be learned to improve the outcomes.

Boaler (1997), as discussed in the introduction to my study stated that, “different teaching approaches influence the nature of knowledge that learners develop and the application of that knowledge”. In her study, Boaler (1997) discovered vast differences between the reform and traditional curriculum in the United Kingdom. She argued that the learners from the reform-oriented school did not have a greater knowledge of mathematics facts, rules and procedures but were able to reason mathematically in assessments and whole class discussion whilst the learners who were traditionally taught had difficulty recalling methods. Although I have adapted Boaler's study to contextualize my research, it needs to be mentioned that this "new curriculum" had been introduced in the United Kingdom in 1988. This means that it had been implemented for almost a decade before Boaler's (1997) study began. The process of implementation in the United Kingdom was not without problems and although it may be expected that within this time its shortcomings might have been "ironed out", this is not necessarily the case. Boaler's (1997) study was situated in the midst of "opposing claims about the merits of alternative teaching", and at the end of her three year study, the reform school's parent body's demanded that the school shift back to the "traditional" approach to teaching and learning mathematics. This indicates that within a South African context we cannot expect change to happen immediately, without contestation on a range of levels and without limitations.

Slominsky and Brodie (2007) have shown how a teacher, Mr. Nemakonde, changed in his practice whilst doing the WITS Further Diploma in Education (FDE) programme, over a period of three years. The FDE programme aimed to develop teachers' professional competence by, "developing their subject knowledge, pedagogical content knowledge (PCK) and educational knowledge" (Slominsky & Brodie, 2007, p.33). In the three year time period, Mr. Nemakonde shifted from an authoritarian view of teaching and learning to a more interactive approach. Slominsky and Brodie (2007) argue that, "developing new practices adaptive to ones own context and competencies is a painstaking and uneven process" (Slominsky & Brodie, 2007, p.44). The teacher in my study may be compared to Mr. Nemakonde in the first year of the research project. The teacher in my study recognized the need for change and saw the importance of involving the learners. He was able to implement the new curriculum in his choice of tasks in the two grades but in whole-class interaction he exerted tight control of the space and time, thus "regulating" the learner's communication (Bernstein, 1982, Brodie, 2007). My analysis in chapter 4 shows that the teacher displayed an uncertainty in his understanding of the new and old curriculum as well as in his view of teaching learning outcome 2 (functions and algebra) in relation to his practice. This means that the teacher was not able to address the progressive nature of learning outcome 2 (functions and algebra) in the new curriculum. In the interview he emphasized the need for teaching procedures to achieve “outcomes”. He did not realize that teaching functions in grade 10 within the new curriculum had shifted from formal definitions and procedures to being more conceptually understood.

The teacher understood some of the purposes and goals of the new curriculum in that he could present higher level tasks (Modau and Brodie, 2008). However, this research reveals that the pedagogical aspects (patterns of interaction) were more difficult for the teacher to implement. The teacher was aware of the new curriculum being implemented in grade 10 but as discussed in section 4.8 previously, he did not realize that its execution would achieve a better understanding irrespective of whether it was practiced in grade 10 or in grade 11.

This means that, had the teacher understood the importance of allowing the learners to reason mathematically, he may have attempted to adapt his practice in both grades. Learner-centered teaching involves a change in content as well as pedagogy and new curriculum training sessions need to emphasize this. This research shows that there is still much to be done in terms of what the teacher learned during training and the implementation of this knowledge into practice. Good teaching needs to be modeled and teachers need to be exposed to the various facets of it, using past research.

Based on this research, I would suggest that teacher training on the new curriculum needs to think seriously on how to help teachers to create a classroom discourse that promotes interaction. This would include teaching learners how to respond to questions appropriately, how to ask questions and how to challenge their peers in argument. These are not skills that learners come to class with automatically. In the analysis of classroom interaction in chapter 4, it was evident that the teacher did not “press” the learners on their responses for a deeper understanding. Training on the new curriculum can also help teachers to generate classroom discussion by focusing the learners thinking and probing them for more critical reflection. This would only be successful if the learners are orientated to the discourse of responding to questions asked. Then only will the learners be able to take ownership of their ideas to express their thinking. Thus, this research suggests that teacher educators need to work with teachers in realizing the various dimensions of pedagogy – tasks and patterns of interaction, and help them to effectively pose questions in whole class discussions to promote mathematical reasoning

In relation to the above discussion, change within a South African context needs to be understood through further research. It seems as though teachers are displaying interesting classroom practices in attempting to make the constructs of the new curriculum a reality. In my study the teacher displayed similarities and differences in his practice in the two grades. He tried to initiate discussion in the grade 10 lessons by asking higher order questions but since he was so focused on explaining rules, he funneled his questions to an answer. This research suggests that "funneling" may be executed as an interaction pattern of the new curriculum as teachers struggle to shift between the "organization of practice" and "knowledge relations" in their lessons (Slominsky & Brodie, 2007). Slominsky & Brodie (2007) argue that many teachers experience difficulty co-coordinating new practices and may loose sight of their focus in trying to implement new roles. Further research is needed to indicate whether funneling is indeed a pattern of the new curriculum.

These recommendations may appear to be "missionary" as the implementation of the new curriculum in South Africa is still fairly new and all the key players are "guarded" in its wake. The challenge for teacher education is to understand the changes that teachers are making in order to develop ways to effectively facilitate the process. Teacher education needs to work out what teachers are doing with respect to the new curriculum and how to move them from there, to where they need to be.

5.4 CONCLUSION

This study indicates that in the light of the new curriculum, the development of new practices will take time. Change cannot occur without risk. Traditional teaching practices have been deeply engrained and teacher's adjustment takes time. Teachers may become so preoccupied with executing new roles that they may lose focus on other aspects. While the intention of the new curriculum is to enable thinking and enquiry among teachers and learners, "it could be seen as a doctrine, with as much authority as the previous one", (Slominsky & Brodie, 2007). Reasons for this include the discriminatory education of the past, the teacher's pedagogical content knowledge, large classrooms and curriculum demands. This research suggests that in an effort to implement the new curriculum, the teacher did not promote reasoning in interaction but struggled to instruct the understanding of procedures in the achievement of outcomes.

From a socio-culturalist stance, instruction should be aimed at developing and supporting the learner's ability to reason. The teacher and learners create zones of proximal development for each other. Both teacher and learners travel intellectually (Brodie & Long, 2004). Just as the learner's voices need to be heard, and teachers need to listen to their developing ideas, so teacher's experiences in doing this need to be understood, and we as researchers need to be sensitive and responsive to their developing ideas. It is clear from this research that some aspects of the new curriculum are harder to achieve than others. Research must identify these in order to help teachers in their journeys.

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APPENDICES

APPENDIX 1.1:

Teacher Interview – Possible questions

1. What practices of yours differed from a grade 10 to the grade 11 classroom?
2. If you could improve on these practices, what would you change?
3. Why did you ask those questions?
4. Are you aware of any differences in the questions that you ask to the grade 10 learners in comparison to the questions you ask the grade 11 learners?
5. What questions would you have liked the learners to ask you?

APPENDIX 1.2

Interview Transcript

	Interview transcript with teacher, Grade 10 and Grade 11 mathematics
Speaker	**Dialogue**
Researcher	Please tell me something about your qualifications?
Teacher	Oh right. My qualifications, I've got a higher diploma in education, then a bachelor of science in mathematics, then an Advanced Certificate in Education (ACE), then an Honors in management.
Researcher	So are you aware of the documented changes in grade ten?
Teacher	Ah, is that in relation to the National Curriculum Statement (NCS), new curriculum, yes.
Researcher	Ja
Teacher	Ah, I am aware because I think for me as a teacher responsible for teaching grade ten; you need to be aware of these policy changes. It also helps you as a teacher to start preparing and taking those learners from where they are to where we want to have them as a country and that means that they must be able to attain those Further Education and training phase (FET) standards at the end of the Further Education and training phase (FET) band.
Researcher	How did you find out about it?
Teacher	I think it was through reading, personal reading and training. Departmental training and also through interaction with my colleagues ah, in a number of field, ah through CIF meetings, clusters and through interaction with subject facilitators and so on.
Researcher	Okay, now in terms of the workshop that you attended, how long was it?
Teacher	The workshop was about five days; I think it was five days, from seven in the morning until half past three in the afternoon. So I don't know how many hours that was.
Researcher	That was only for grade ten and now for grade eleven have you attended more training?
Teacher	It was for both grade ten and grade eleven. Ahh, last year I attended grade eleven workshops and the year before it was for grade ten.
Researcher	Okay, what do these changes mean for you?
Teacher	Mmm, to me as a teacher, I think it implies that I must be innovative in terms of my teaching because the curriculum is still new and I, I, I cannot take anything for granted, my planning must be designed down. I need to know where am I taking these learners too, unlike in the traditional way of teaching, we could just teach anything but now you must be aware of where or what you want them to achieve at the end of the day.
Researcher	Okay, umm, do you think questions are important in the classroom?
Teacher	It is very important that you should have questions, you know on an ongoing basis because if you ask them the questions you also gain their understanding in terms of the concepts that you teaching them. So on a number of times; you must engage these learners by asking them questions just to get feedback from them.
Researcher	Okay, um describe to me what happens to you in the class when you ask questions?
Teacher	*(Laughter)* What happens to me? At the time when I ask questions?
Researcher	Because I notice, you ask many questions.

Teacher	Yes, at the time when I ask questions, I think over and above from getting a feedback from the learners, I also want to see, those learners who are not listening and also those who can see or think outside the box, you know I always listen to the answers that they give me and also they come to their solutions very quickly and see if these learners understand what I'm talking about in the classroom.
Researcher	Okay, umm, now, when you ask a question to the learner, what goes through your mind when the learners give an incorrect answer? Or when the learner's don't answer because I noticed in your classes when you ask a question, they don't answer, so what do you experience?
Teacher	Ja ja, at that time when they don't answer. I get frustrated. I always pose my questions in such a way that they become easy to understand but I get frustrated when the solution doesn't come and on a number of times I will repeat the question, phase it differently but when the solution doesn't come, I end up giving out the answer and I know I shouldn't be doing that, you know because if I give out the answer a lot then these learners don't actually do anything.
Researcher	Okay, now did you notice that when you ask a question and if they don't answer, do you notice that they probably know how you teacher so that's they don't answer. Do you think that, that could be happening?
Teacher	I, I, I, never thought of that but I think it could be correct, it could be correct that maybe it's because of my style of teaching, that he is probably going to give us the answer anyway. Ja I think that would be a correct, you know observation.
Researcher	Okay when you ask a question, do you have a predetermined answer in your mind?
Teacher	Yes, I think, its not really a predetermined but at that time when it happens, when I'm asking questions its because of the circumstances, but I know how the learners are going to respond and how they should be responding but its not really necessarily a predetermined answers but I know how they should be responding consequently.
Researcher	Umm, I noticed that you tend to explain when you don get a correct answer from the children, why do you do that?
Teacher	*(Laughter)* Jam, like I said I think you see the teaching of mathematics requires you as a teacher to be impartial and let the learners understand the procedures on how the outcomes should be achieved because if you only give them answers without explaining to them how things must be done then I don't think that's actually fair because at the end of the day as a teacher you only want them to understand how concepts are applied. I think that is why I'm always explaining to them why things must be done.
Researcher	Okay, why don't you like, why don't you choose a particular learner in class and keep asking that particular learner to explain his reasoning. In mathematics we call it press.
Teacher	Ja, ja, ja
Researcher	Pressing the learners for an answer, why don't you do that in your teaching?
Teacher	I, I, I believe in in in collaborative or team or group learning
Researcher	Okay
Teacher	And my class has always been a group. And I always want to group these learners in different groups where they compete so if I always become, you know much in a particular learner then the other learners will become distracted and will loose interest in the lesson so that is the reason why I always make sure that everyone of them *(inaudible).*

Researcher	Okay at the end of the lesson, what gives you an indication that the learners understand what you are talking about?
Teacher	I think one is uhh, the nature of the questions that I ask at that time I I check that most of the questions were answered correctly but secondly its not even for me to see, if the learners have understood what I was teaching about unless if I give them extra work which they have to go and do with their friends or something like that or they can do in the classroom just to get a feedback or their understanding.
Researcher	Okay what questions of yours differed from grade ten class to the grade eleven?
Teacher	Ahhh, I think with the grade eleven's I know that my teaching was different and I think it was because of the curriculum. With the grade eleven's, you know I'm always assuming that these learners have background knowledge of certain concepts, ahhh, I give them a lot of info which they must think about at their own time and try t make sense out of it, but with the grade ten's, NCS, these learners must you know, they must discover things at that time you know under my supervision so they are able to ask me those questions that they are not clarified are but with the grade eleven's the assumption they know most of these things, even if they don't know but they will go out and find out for themselves.
Researcher	If you could improve on your questions that you ask in the class what would you improve?
Teacher	Of what?
Researcher	What would you change?
Teacher	If I could improve on my questions
Researcher	Or even the style of presenting the questions, what would you change?
Teacher	What will I change? I think I will change from giving a lot of answers. Ja giving a lot of answers unnecessarily because I have also realized that I ask a lot of questions and also you know, answer those questions myself *(inaudible)*.
Researcher	What are your expectations from the learners in the classroom?
Teacher	Well I also want them to participate in the classroom and I also want them to produce better symbols you know, better marks in and also to see that they use math's out of high school if they want to pursue certain careers hat are scarce in this country.
Researcher	Now you know, in the grade ten and grade eleven class, did you know the learners well?
Teacher	No, I did not know them well I think wit the grade eleven's I knew them better because they were fewer, with the grade ten's.
Researcher	You only taught them last year?
Teacher	Ja only for last year.
Researcher	And with the grade ten's?
Teacher	With the grade ten's, also for last year.
Researcher	Do you think that maybe if you would've known them better they would contribute better to your class?
Teacher	I should think so. I should think so. Because even though I didn't know all of them I could tell what their strengths and weaknesses are so I think if I would've spent more time with them I would've known them better.
Researcher	And would that have contributed better to the way you would've expected them to answer?

Teacher	Ja, I think so, I think it would've contributed better, because then I would've known that each particular learner would see thing this way and without giving too much information, I would've expected something from that learner you know but because I didn't know them, I was giving out allot of information unnecessarily.

APPENDIX 2.1

Grade 10 1st Task

THE EFFECT OF THE PARAMETERS a AND q

$$y = a \sin(x) + q$$
$$y = a \cos(x) + q$$
$$y = a \tan(x) + q$$

ACTIVITY 1

$y = \sin x$

1.1 Copy and complete the table below:

x	0	30	60	90	120	150	180	210	240	270	300	330	360
y													

1.2 Sketch a neat graph based on the information you found above.

1.3 Now sketch the graph of $y = 2 \sin x$. What do you notice?

1.3 Using a table of values draw a neat curve of $y = 2 \sin x + 1$

MODELLING

2.1 The following fractions have been converted into decimal form :

$\frac{1}{3}$ = 0,3333333333...............................

$\frac{2}{11}$ = 0,1818181818................................

$\frac{1}{37}$ = 0,027027027.................................

2.1.1 Why are these numbers called reccuring decimals ?
2.1.2 Study the decimal fraction of $\frac{1}{37}$. Describe the pattern for this number.
2.1.3 The decimal fraction for $\frac{1}{13}$ is 0,076923076.
This recurring decimal repeats after every 6 decimal places.
Write down the next 6 decimal places.
2.1.4 The table below shows rainfall as measured in Durban over a year

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
120	110	90	60	45	40	50	75	90	115	120	130

Sketch a graph of annual rainfall recorded for the months of the year .
NOTE: REAL LIFE EXAMPLES WILL NEVER FIT A TRIG GRAPH PERFECTLY , SOMETIMES WE MAY NEED TO MAKE ASSUMPTIONS

APPENDIX 2.2

Grade 10 2nd task

GRADE 10 MATHEMATICS

THE EFFECT OF THE PARAMETERS a AND q

$Y = ax^2 + q$

ACTIVITY 1

(work in groups of FOUR or FIVE)

$Y = x^2$

1.1 Copy and complete the following table by using the equation above .

X	- 4	-3	-2	-1	0	1	2	3	4
y									

1.2 Sketch the graph using the values you found in 1.1

1.2 What happens to your graph as the x-values continue to increase ?

1.3 Sketch the graph of $y = 2x^2 - 8$ on the same set of axes with the graph you sketched in 1.2

1.3 Compare the graph of $y = x^2$ with that of $y = 2x^2 - 8$. What do you notice ?

1.4 What is the minimum y – values of the two graphs ?

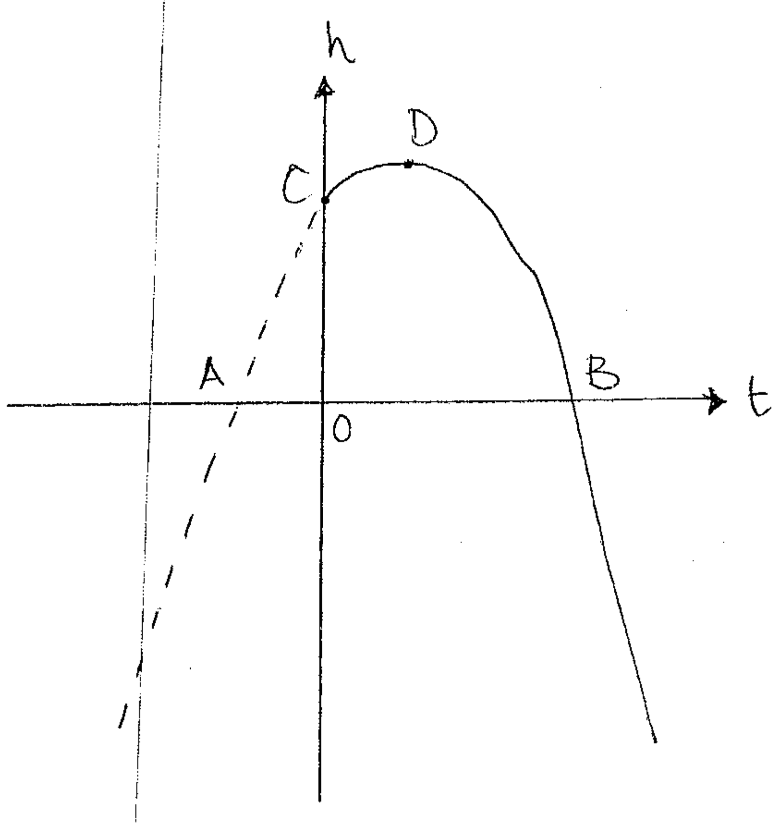
1.5 Now sketch the graph of $y = -x^2$. Does this graph have a minimum or maximum turning point ? Why is that ?

1.6 Sketch the graph of $y = -2x^2 + 8$

APPLICATION

Lundi's height h (in metres) above the water during a somersault dive is given by the equation $h = -6t^2 + 3t + 3$, where t is the time in seconds after he leaves the diving board. A graph showing the relationship between the height above the water and time is shown below. Study the graph and then answer the questions that follow.

Grade 10 2nd task cont.



1. Explain why part of the line is represented by a dashed line .
2. What is Lundi's height above the water at $t = 0$? Which point on the graph gives you this answer ? What does your answer tell you about this problem ?
3. After how many seconds does Lundi enter the water ?
   Where do you read this value on the graph ?
4. After how many seconds is Lundi 3m above the water ?
   Explain how you found your answer .
5. Now find Lundi's maximum height above the water .
   Where do you read this value on the graph ?

APPENDIX 2.3

Grade 10 3rd task

GRADE 10 MATHEMATICS

THE PARABOLA $Y= a x^2 + q$

GRAPH SKETCHING

It can be time consuming to plot every parabola using a table of points. In order to do this we must determine the key points necessary to allow us to make a sketch graph of the parabola.

SKETCH THE FOLLOWING GRAPHS

1. $y = x^2 - 9$
   (Show all the necessary details)

2. $y = -x^2 + 4$

3. $y = 3x^2 - 12$

APPLICATION

A stone is dropped from the top of a building . The stone's height (h) in metres , t in seconds after it has been dropped , is $h(t) = -5t^2 + 80$

(a) Draw a graph to represent this function.
(b) Find h (2) and explain what this value means.
(c) From what height is the stone dropped ?
(d) How long does it take the stone to hit the ground ?
(e) After how many seconds will the stone be approximately 35 m from the ground ?

APPENDIX 3.1

Grade 11 Task

GRADE 11 MATHEMATICS

TRIGONOMETRIC GRAPHS

Question 1

1.1 On the same set of axes draw neat sketch graphs of of the function $y = 3 \cos x$ and $y = \tan\frac{1}{2}x$ for $[0^0; 360^0]$ Clearly show the intercepts with the axes and all turning points . Draw the asymptotes using a broken line.

USE THE GRAPHS IN 1.1 AND ANSWER THE FOLLOWING QUESTIONS.

1.1.1 What is the period of the function $y = \tan\frac{1}{2}x$?

1.1.2 What is the amplitude of the function $y = 3 \cos x$?

1.1.3 Write down the equation of the asymptote.

1.1.4 Show on the graph , using A , where the solution to $3 \cos x = \tan\frac{1}{2}x$ can be found.

1.1.5 What are the co- ordinates of the turning point?

Question 2

On the same set of axes draw sketch graphs of $y = \tan 2x$ and $y = -2\cos x$ and indicate the intercepts with the axes and turning point

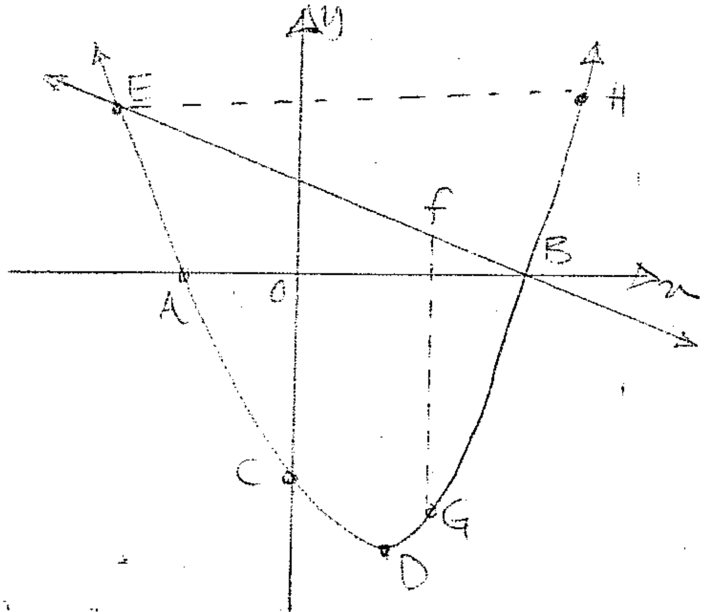
APPENDIX 3.2

Grade 11 Task

Gr 11 Mathematics . SG Worksheet
05 Sept 2006

Activity 2

1. The straight line EB cuts the parabola $y = 2x^2 - 3x - 2$ at E and B and is parallel to $y + x = 0$.



a) find the coordinates of A, B, C and D
b) find the equation of the line EB
c) find the coordinates of E
d) find the length of fG if the x-coordinate of both F and G is 1
e) H is the point (K; 3) : find K.

APPENDIX 3.2 CONT.

Gradell

2. Sketch each function on a separate system of axes, by finding the axis of symmetry, turning point, Range and the intercepts on the axes.

a) $y = x^2 - 2x - 3$

b) $\frac{5 - y}{x} = x + 4$

3. The sketch shows the graphs of $f : x \to x^2 - 4x - 5$ and a linear function g.

a) find the lengths of OA ; OB ; OC , OE and ED

b) What is the equation of the dotted line

c) What is the length of BC

d) find the equation of g.