

DIALOGICAL RELATIONS IN A MATHEMATICS CLASSROOM

by

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Abstract

This case study investigated the polyphonic discourse in a beginning secondary school mathematics classroom in Trinidad. It relates how classroom and research interview ‘talk’ contributed to students’, their teacher’s and the researcher’s developing conceptions of mathematics, themselves and each other. The study is approached from dialogical and socio-constructivist orientations.

Students and their teacher professed a diverse set of prior conceptions of mathematics which included viewing mathematics as rule based with a problem solving orientation and emphasizing attention to the teacher. Several cases are reported that describe the authoritative elements which included a well defined structure to lessons mirroring the textbook, ‘cloze’ questions, and a reliance on rules and absent historical referents as justifications for mathematical activities and substitution for mathematical reasoning. Student and teacher questions and their desire to understand, however, served to interrupt the monological discourse. What was internally persuasive for students was the relational competency of their teacher as well as the communicative acts of their peers. Students’ responses to pedagogy were internally persuasive for the teacher and precipitated ideological assessment. Both discourse types contributed to the formation of individual as well as social identities. Student and teacher utterances were internally persuasive for the researcher.

I recommend that research needs to attend more meaningfully to what is internally persuasive for students and teachers in mathematics teaching and learning. In addition I theorize on the need for a dialogical relationship between dialogue and pedagogy that is attentive to the ambiguities in communication.

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CHAPTER 1

TALK BUILDS COMMUNITIES

At the interdisciplinary Critical Thinking in Teaching and Learning Symposium held at the University of the West Indies Saint Augustine campus in January 2004, a professor of engineering, in closing his presentation, stated that “talk doh build nutten (talk doesn’t build anything).” He was promptly and gently rebuked by his colleague, a professor of linguistics, who succinctly pointed out that “talk builds communities.”

This single utterance, that ‘talk builds communities’ has had a tremendous impact on my thinking. In proposing, researching, writing, and re-writing this thesis I have become ever more cognizant of how these two things, talk (or text) and community are reflexively and reciprocally related to each other. This thesis embodies that statement as it reveals how the talk of participants in a single mathematics classroom shaped the identities and relationships in that community and of the community. Indeed, my own identities, as researcher and participant in the community, were shaped by the ‘talk’ that I was privileged to observe, record, and in which I participated. Consequently, I have become painfully aware of the fact that while we cannot fully direct the intentionality of our utterances we must, nevertheless, take responsibility for what we say and to some extent how it can be interpreted, as our utterances as researchers also contribute to the development of the communities that we study. This awareness, that is necessarily incomplete, of the unintended consequences of our words and deeds, places an awesome responsibility on educational researchers and on individuals who work in education in general, not only for the things that we say or fail to say, but also for the identities of the individuals and communities that we share in building and build in sharing.

This thesis aims to portray the heteroglossia inherent in a social situation, namely a secondary school mathematics classroom. Several over-lapping and inter-related voices will be re-presented. These voices include those of the teacher of the mathematics class, Saraswati, her students and my own. However these are not the only voices present in the thesis, and indeed even these voices speak others' words and thoughts and convey others' beliefs and values. It is thus important at this point in the thesis for me to articulate and circumscribe my own authorial voice, identity, values, beliefs and conceptions before presenting others'.

Prior to beginning post-graduate study in Canada I had taught at a secondary school in Trinidad for a period of five years. While employed as a mathematics teacher initially, over the years I found myself with fewer and fewer mathematics classes and, ultimately, none. Over the same period, outside of the classroom setting, I was involved with the preparation of high achieving students in the local Mathematics Olympiad as well as tutoring individual students in secondary mathematics. While interacting with students in the Olympiad I observed the difficulties that many had with 'doing' mathematics which was different from the algorithmic problems to which they had become accustomed and which they expected. Indeed as a former participant I remembered it all too well. In my tutoring experiences I began to appreciate how much of school mathematics remained mysterious and 'magical' even for students who did well on terminal examinations. They frequently recounted that the reason they did it 'that way' was because that was how they were 'told' to do it and were always on the lookout for the teacher's 'trick'. I also observed both the satisfaction that students felt when a previously taken for granted rule or statement was demystified and demythologized through our joint efforts at proving, as well as their resistance and apprehension when

asked to step outside of the prescribed curriculum guidelines and attempt non-standard questions.

Like the teacher in this study, and many teachers at the secondary level in Trinidad and Tobago I have not (yet) had formal 'teacher preparation' courses as this is done via the in-service postgraduate Diploma in Education. This is a problematic, confusing, conflicting and sometimes painful space from which to operate as 'one is already' even while 'one is becoming' a teacher. Despite this uncertainty I have always felt myself to be an enthusiastic teacher in whatever discipline I was asked to teach. While I view helping students to succeed in terminal (consequential) examinations as important, this has always been secondary to my belief that such success would follow if they were to become passionately engaged with the subject matter. Thus, I viewed my task as helping students to find something in and about mathematics that engaged them. The reality however, like that for many other teachers, was a subordination of my pedagogical desires to the dictates of institutionalized curriculum and 'ends-oriented' societal Discourses.

The voice with which I have attempted to write is not the voice of a mathematician, though my mathematical training and experiences do contribute to it; it is not the voice of a pedagogue for my intent is not to instruct, which is not to deny that there are didactic dimensions to my voice. And although I have attempted to adopt an ethnographic perspective and voice, I have found it difficult to maintain the 'otherness' and 'outsiderness' required by classic ethnography as I engaged in enquiry in my own culture. I have found that it too is not really my voice. At such times one can attempt to maintain an 'academic' dichotomy between researcher and research subjects, author and reader, but in social settings, even reading and writing, one ultimately becomes aware of

the awesomeness (and overwhelming responsibility) of being a human being, in dialogue with, and responding to other human beings. This is the voice that I hope to speak with in this corpus of work.

In my last year in school before deciding to pursue graduate studies in education I had become very frustrated and disenchanted with the micro and macro politics governing teaching and learning in secondary schools in Trinidad and Tobago. As a result I began to dissociate myself from activities and verbal interactions with others in school and instead engaged in introspection and internal dialogue. I began to wonder more about the ways in which debilitating and enabling patterns of conceptions and concomitant behaviors were reproduced in school systems, and specifically in mathematics classrooms. What happened when teachers, students and cultural artifacts, such as textbooks, interacted in a mathematics class?

In attempting to visualize my thinking I drew a simple directed graph with the three nodes representing the three groups – teachers, students and artifacts connected by arrows to demonstrate the (perceived) possible directions and strengths of each one's influence on the others. As I read more I came to realize that I was not really interested in the nodes themselves but in the arrows, and indeed not in terms of the direction of causality but in terms of *patterns of interaction* and influence. I still lacked however the theoretical and conceptual tools that would be necessary to make sense of my own questions.

In attempting to make sense of the diverse forms of interaction in a mathematics classroom I considered recasting them not as behaviors alone, nor as cognitions, but to see interactions ultimately as forms and patterns of communication. This proved a productive avenue into my thoughts as well as the mathematics research literature.

A special issue of *Educational Studies in Mathematics* in 2001, (Volume 46) spoke directly to my growing research interests. Kieran, Forman and Sfard (2001) in their editorial suggested that as mathematics education research has matured and diversified, its attempts to identify universal individual cognitive constructions of mathematical representations have been paralleled by an emerging recognition of the important ways in which the socio-cultural environment, especially language, influences the development of mathematical dispositions. Thus, attention has been focused on the means through which such influences are mediated in and by the daily transactions that occur in the mathematical community of the classroom (Sfard, 2001). Consequently, greater attention is being paid not only to *what* is communicated in the mathematics classroom but also to *how* it is being communicated. What is communicated supersedes disciplinary content knowledge and includes attitudes, beliefs, values, and norms (Bishop, Seah & Chin, 2003; McLeod, 1992). It is suggested that this approach, whose object of study includes language and communication, forms a distinctive research framework in mathematics education research, and can be termed *discursive* (Kieran, Forman & Sfard, 2001).

In order to understand how diverse conceptions are communicated, research must attempt to address directly the *relationships* between what schools do, what teachers do and what children learn from their engagements in mathematics classrooms. This focus on *interaction as communication* led me to consider communication as forming, entering into, affecting, and being affected by relationships with multiple simultaneous others. How to frame these relationships became my next concern.

There are numerous ways in which such relationships could be conceptualized. One of these mentioned previously is to view what goes on in classrooms as discourse

(Kieran, Forman & Sfard, 2001) and to view such discourse as heteroglossia or a “polyphony of social and discursive forces” (Holquist, 1990, p. 69). This dialogical view of a mathematics classroom, drawing on the work of Mikhail Bakhtin and other scholars, is recommended by van Oers (2001) who argues for an analysis of classroom discourse from a (situated) socio-cultural perspective. From this perspective the multiple simultaneous discourses in a mathematics classroom, constituted by, but not restricted to the voices of students and teachers, might be considered not a dialogue but a ‘polylogue’, “a polyphonic discourse among all possible voices that helped to create the history of that community” (van Oers, 2001, p. 74). Several concepts of Bakhtin: dialogism, heteroglossia, polyphony, authoritative and internally persuasive discourse, provided the conceptual tools I needed to study and understand the nature and functioning of relationships in the discourse of a mathematics classroom.

Purpose

The purpose of this study was to examine the relationships between the ‘polyphonic discourses’ of a mathematical community and the developing mathematical conceptions among members of the community.

Definitions

There are many ways to define **discourse**. In this thesis I adopt the perspective of Gee (2004) in distinguishing between ‘big D’ Discourses and ‘little d’ discourses. The latter category refers to ‘language in use’ and is frequently used to refer to the way in which language is used on-site in the service of constructing events and identities. Big D Discourses involve the recruitment of extra linguistic “stuff” such as “one’s body, clothes, gestures, actions, interactions, symbols, tools, technologies, values, attitudes, beliefs and emotions...”(Gee, 2004, p. 7) in order to be seen as belonging to a specific socially

constructed group or engaging in specific socially constructed activities. For example, in this study there are the socially delimited categories of mathematics teacher, secondary student, and educational researcher.

Polyphonic discourses are discourses in which multiple voices interact and contribute to the maintenance and/or development of the discourse. They are inherently heteroglossic. The speakers in these discourses may or may not be physically present to one another and the utterances and replies that constitute the discourse may be widely separated in time.

In this study I viewed a **mathematical community** as that constituted by the different voices/discourses that shared the same physical space at the same time on an ongoing basis. This definition, I believe, allowed me the scope to choose a suitable grain size for analyzing discourse and to focus on a single classroom as a mathematical community.

According to Mji (2003) “Conceptions of learning, describe variations in interpretation of students’ experiences of learning...The conceptions are specific meanings attached to phenomena, and these mediate responses to situations involving the phenomena” (p. 688). Further, in mathematics classrooms Boaler (1999) notes that,

students do not only learn mathematical concepts and procedures; they learn how to interact in the classroom; they learn particular sets of beliefs and practices and they learn the appropriate way to behave in the mathematics classroom. The different interactional patterns of the mathematics classroom do not accompany the students’ learning, they constitute their learning. (p. 261)

Thus, **conceptions of mathematics** are here defined as the personal *interpretations* that participants in a mathematical discourse hold or come to hold about the teaching, learning,

knowing or doing of mathematics. These tacit understandings may include attitudes, beliefs, values, or norms about mathematics teaching, learning and mathematical interactions and do not refer to conceptual understandings of mathematical content. They are the meanings that participants in the discourse make for themselves from their interactions in the community. As Love and Tahta (1991) suggest, ‘conception’ better conveys the dynamic and developmental meaning of “a conceiving and a growing” (p. 254) than the noun ‘concept’ does.

Other terms that might be unfamiliar, problematic, or which I use in a specific and deliberate way will be defined in the relevant contexts where they occur. This does not preclude the existence of some terms, which may be defined more narrowly and for specific purposes in different theoretical frameworks, and which I have used here in their more general sense.

Research Questions

The central research question organizing this study was, “How do the polylogical discourse patterns in a mathematics classroom relate to the development of conceptions of mathematics among students in their transition from primary to secondary school?”

Specifically, I address the following questions:

What conceptions of mathematics do participants in the mathematical community of a beginning secondary school classroom initially bring to the discourse?

What are the major discourse patterns in a beginning secondary school mathematics classroom?

Who are the voices in these discourses?

What are they saying (explicitly or implicitly)?

How are these voices/discourses interpreted by the members of the mathematical community?

How do the discourse patterns interact with one another?

Do these patterns influence the conceptions of mathematics that the participants in the ongoing discourse hold or come to hold?

What type of relationships do these discourse patterns foster?

The first of these questions is addressed in Chapters 4 and 6, while the remaining questions are explored in both Chapters 7 and 8.

Significance of Study

The study of conceptions of mathematics is considered to be important in understanding the relationship between the cognitive, affective and conative aspects of mathematical problem-solving (Leger, Pehkonen & Torner, 2002). Further, research suggests that the junior high school/early secondary school may represent the most important period for determining students' attitude towards mathematics as it relates to later achievement in mathematics (Ma & Kishor, 1997). Calls have been made in the literature to better understand how debilitating conceptions of mathematics are acquired, develop, persist, and ultimately, can be challenged and changed (Pajares & Miller, 1994). Thus, there exists a need to deepen our understanding of the extent to which classroom discourse enables or restricts access to mathematical ideas through its potential influence on conceptions of mathematics (Boaler, 1999).

By focusing on the dialogical relations of students in transition from one mathematical community to another, primary school to secondary school, this study hopes to be able to further our understanding of these problems regarding the development of debilitating and enabling conceptions of mathematics.

Boaler (2002) points to the fact that, “[a]s students engage in classroom practices, and mathematical practices, they develop knowledge and they develop a relationship with that knowledge” (p. 16), which contributes to the development of their mathematical identity. This she defines as “the knowledge they possess, as well as the ways in which students hold knowledge, the ways in which they use knowledge and the accompanying mathematical beliefs and work practices that interact with their knowing” (pp. 16–17). Thus by focusing on classroom mathematical practices/relationships framed as dialogue this study may also contribute to a better understanding of how students’ mathematical identities develop.

Many countries, including Trinidad and Tobago, are concerned with the quality of their mathematics education (Republic of Trinidad & Tobago, Ministry of Education, 2002). Efforts to reform mathematics programs in Trinidad and Tobago parallel similar projects in North America such as the National Council of Teachers of Mathematics’ standards projects (NCTM, 1989, 2000). In attempting to guide reform Middleton, Sawada, Judson, Bloom, and Turley (2002) suggest that relationships should be attended to. As they state, “reform emerges from relationships” (p. 429). In the complex network between students, teachers, administrators, parents, boards, governments, the wider society and cultural artifacts such as textbooks and instructional materials, attention to relationship should be of critical concern in trying to engender the conditions under which reform initiatives can truly emerge. It is in this context I believe that more appropriate mathematical beliefs could be nurtured and the goal of lifelong democratic access to powerful mathematical ideas, identified by English (2002) as a priority theme for mathematics education research, become more likely to be attained. Thus, by focusing my attention on relationships in a mathematical community and framing them as

dialogue/polylogue I hoped to attain a better understanding of the way in which discourse influenced the development or reinforcement of conceptions of mathematics.

This study also attempts to paint a rich picture of the dialogical processes and patterns in a single mathematics classroom. Since the dialogical patterns of individual classrooms are likely to be different, the results are unlikely to be generalizable beyond the context. However, it is hoped that while it may not provide prescriptions for practice in general, it may provide descriptions for practitioners and draw attention to the dialogical nature of discursive relationships in other mathematics classrooms.

Theoretical Framework

This study is framed within a theoretical space drawn from several perspectives. These include the Bakhtinian idea of dialogism, social constructivism and teachers' and students' conceptions of mathematics. These concepts are outlined below and developed more extensively in Chapter 2.

Dialogism

Dialogism views dialogue as central to consciousness that is historically and socially situated, that meaning is achieved through struggle and that texts are always in production (Holquist, 1990). Within a mathematics classroom there are multiple voices; utterances, replies, and relations between these which constitute an ongoing dialogue. Of this triad of utterance, reply and relation, relation is viewed as most important since it unites the other two and allows them to have meaning. In a classroom the predominant voices in dialogue are those of the teacher, the students and socio-cultural artifacts such as textbooks. The relations between these when viewed through a dialogical lens are in a constant process of construction, deconstruction and reconstruction.

A dialogical conception of a mathematics class allowed me to consider the simultaneity of multiple dialogical relations by focusing on the language of discourse. However, since “dialogue is carried on at different levels by different means” (Holquist, 1990, p. 41) my observations and analysis also had to be attentive to these different levels.

In dialogism, the observer of the relation between two entities in dialogue is necessary to provide a center from which the nature of the relation can be understood. Such an observer becomes a part of the dialogue, or as Holquist (1990) says he is, “simultaneously an active participant in the relation of simultaneity” (p. 21). Thus an observer from this perspective experiences reality from a particular position and consequently, “whatever is observed is shaped by the place it is perceived”(Holquist, 1990, p. 21). Since my interaction with the community over time was itself a dialogue I needed to be attentive to my own voice and its influences on the dialogues of the community.

Social Constructivism

This study is situated within a social-constructivist framework. Ernest (1997) asserts that such a research approach in mathematics education emphasizes the importance of the constructions that individuals bring with them, the social context in which teaching and learning occurs and an attention “to the beliefs and conceptions of knowledge of the learner, teacher and researcher...” (p. 31). Within this framework Ernest (1997) also points to the role of ethnomethodological studies as being concerned with recording “human phenomena in terms of participant understandings” (p. 33) and the importance of case studies as a vehicle “to illuminate the general through the particular” (p. 34).

Boaler (1999) describes socio-cultural perspectives as not being focused on the “cognitive attributes that individuals possess, but upon the ways in which those attributes play out in interaction with the world...” (p. 260). She argues that they “turn the focus away from individual attributes and towards broader communities” (p. 261) and that such perspectives “broaden the focus of research to highlight the beliefs, practices and interactions that constitute learning within different communities” (p. 278). Thus, they form a suitable framework for studying the influence of community activities on the development of conceptions of mathematics.

Dialogism and social constructivism are compatible frameworks since both see meaning as emerging from the interaction of selves with a historically produced and situated socio-cultural community. For dialogism though, it is in the relation, *dia logos*, in and through language, that meaning emerges. Indeed Wells (1999) suggests that while many socio-cultural theorists draw on Vygotskian theory their theoretical foundation is to be found in Bakhtin’s work on dialogism.

Teachers’ and Students’ Mathematical Conceptions

Teachers’ mathematics related conceptions have been studied under the basic assumption that what teachers believe plays an important role in “what gets taught, how it gets taught, and what gets learnt in the classroom” (Wilson & Cooney, 2002, p. 128). A significant body of evidence has been accumulated regarding the importance of teachers’ conceptions for enacting the curriculum (Wilson & Cooney, 2002; Lerman, 2002; Lloyd, 2002). Much of this research has been qualitative in nature involving case studies of a few teachers and focused on problems involved in changing teachers’ conceptions. This study did not attempt to change conceptions of mathematics but to describe how the

polylogical discourse of a mathematics classroom was interpreted by participants in the discourse and influenced their conceptions of mathematics.

A rich literature exists on the numerous conceptions that students have about mathematics (De Corte et al., 2000; McLeod, 1992; Schoenfeld, 1992). These and other studies suggest that not only are mathematics related beliefs important for later success but that it is important to help students develop enabling mathematics related beliefs from as early as possible and that the early years of secondary school may be the most important in this quest. Thus, the study was conducted with students at the earliest point in their Secondary academic careers, the first three weeks of their transitioning to secondary school from primary school.

This thesis works from the premise articulated in the opening paragraph that “talk builds communities” but seeks to go beyond this to draw attention to the ways in which community talk/dialogue contributes to the development of mathematical identities through its influence on one’s conceptions of mathematics. It attempts to engage the authoritative position that “talk doh build nutten,” which offers little reason to take responsibility for what our utterances, mathematical and otherwise, do *in* and *to* the world.

Some of the central themes that run through the thesis include not only the notion of dialogism but of communication, relationships and the incumbent responsibilities associated with being in communicative relationships. This is a story about individual as well as collective identities. It is also a story about mathematics education. It is a story about relationships that are fraught with desire, tension, uncertainty and ambiguity. It is a story of many voices represented largely, but not exclusively, in my own voice and from my perspective as a dialogical observer as well as participant.

CHAPTER 2

HALF SOMEONE ELSE'S

The word in language is half someone else's. It becomes "one's own" only when the speaker populates it with his own intention, his own accent, when he appropriates the word, adapting it to his own semantic and expressive intention. (Bakhtin, 1981, p. 293)

In all areas of life and ideological activity, our speech is filled to overflowing with other people's words, which are transmitted with highly varied degrees of accuracy and impartiality. (Bakhtin, 1981, p. 337)

In this section I draw on some of the research literature, others' words, that have been in dialogue with me and which have informed my view of mathematics classrooms and thus have contributed to shaping the purpose and analytical framework of this study.

Goals of Mathematics Education

A quarter century or more of re-conceptualizing what it means to know and do mathematics has witnessed changes from a view of mathematics as a "collection of abstract concepts and procedural skills to be mastered" to "a set of human sense-making and problem-solving activities based on mathematical modeling of reality" (De Corte, 2004, p. 280). Consequently, the ultimate goal of a mathematics education is now seen not simply to be an acquisition of or proficiency with isolated mathematical rules, concepts, and procedures but the development of what has been called "a mathematical disposition" (De Corte, 2004). The components of such a disposition, according to De Corte, Verschaffel and Op' T Eynde (2000), include mastery of domain specific knowledge, mastery of heuristics, meta-knowledge proficiency, self-regulatory skills and positive mathematics related beliefs. This "mathematical disposition" is very similar to the conceptualization of successful mathematics learning termed "mathematical proficiency" put forward by Kilpatrick, Swafford and Findell (2001, cited in Boaler, 2002)

where the interconnected components are conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and a productive disposition. This latter category, productive disposition, is explained as the “habitual inclination to see mathematics as sensible, useful and worthwhile, coupled with a belief in the value of diligence and in one’s own efficacy” (RAND mathematics study panel, 2002, p. 9) while in De Corte et al’s categorization positive mathematics beliefs refer to “beliefs about the self in relation to mathematical learning and problem solving, about the social context in which mathematical activities take place, and about mathematics learning and problem solving” (De Corte, 2004, p. 282). Both of these categories thus emphasize and recognize the importance of non-cognitive outcomes as being an important part of a mathematical disposition/proficiency and draw attention to the fact that mathematical activity in school takes place in a particular social context. Recognition of the importance of attending to these non-cognitive outcomes in mathematics education is evident in the stated goals for mathematics education articulated in the Trinidad and Tobago secondary school curriculum guide for mathematics (Republic of Trinidad & Tobago Ministry of Education, 2002). These goals include, “To develop self-reliance, honesty, open-mindedness, confidence and perseverance...To promote appreciation of the role of mathematics... [and] to promote positive attitudes and values in students” (Section 2-3).

Globally, an important goal for mathematics education is lifelong, democratic access to powerful mathematical ideas (English, 2002). Part of achieving this goal involves helping *all* students to develop healthy or enabling mathematical dispositions. Furthermore, this requires helping students to develop positive conceptions of mathematics and mathematics education. Thus, understanding how conceptions of

mathematics and mathematics education develop becomes an important task for mathematics education research.

Fueling these re-conceptualizations of mathematics and mathematics education has been a number of theoretical perspectives that challenge the perception of knowledge as observable facts and the associations between them, which can only be validated through observation and experimentation and which exists ahistorically and independently of individual knower's social and cultural conditions (Wells, 1999). It is to these 'constructivisms' that I turn in the next section.

Constructivisms

At present, there is a lack of consensus as to whether constructivism is an epistemology, a learning theory or a teaching approach and indeed it may be all of these things (Lederman & Flick, 2004). In this section I do not engage with this debate but attempt to briefly delineate the topography of the constructivist terrain and describe the perspective that seems most synchronous with the way in which I view mathematics classrooms.

According to Davis and Sumara (2003), "there is no 'constructivism', but, rather, a diversity of discourses that have been clustered together...under the constructivist banner" (p. 125). This diversity is delineated in Phillips (1995) who identifies conceptual influences such as Von Glaserfeld, Kant, Alcoff, Potter, Kuhn, Piaget, Vygotsky, Dewey, and James among others in attempting to categorize the various species of constructivism. Central to all constructivist discourses, however, are the epistemological propositions that knowledge is *actively constructed* by the learner and not passively received from teachers or the environment and that coming to know is an adaptive process in which the learner does not discover some objective, preexisting world (Lesh, Carmona & Hjalmarson,

2003). This is similar to Davis, Sumara and Luce-Kapler's (2000) suggestion that the various constructivist discourses converge around the issues of dynamics, coherence and a rejection of "representationist" accounts of cognition.

Phillips (1995) provides a framework which divides constructivisms along three dimensions. The first dimension, "individual psychology versus public discipline" (p. 7), identifies the *subject matter* concerns of constructivists. The public discipline pole concerns itself with how human knowledge in general is constructed while the former seeks to understand how individual learners go about constructing knowledge. Mathematical conceptions are here viewed as individually held constructions. The second dimension, "humans the creators versus nature the instructor" (p. 7), is concerned with the *processes* by which knowers come to know. The issue here is whether through the influences of other minds together with sociopolitical factors new knowledge is made or whether nature provides a template from which new knowledge is discovered. My view of mathematics classrooms tends towards the former position. The third dimension also concerns the processes involved in knowledge construction in terms of whether it is seen as individual cognition, socio-political processes or some combination of both and whether this activity is physical, mental or both. The poles of this dimension might be represented by radical constructivists such as Piaget and Von Glaserfeld at one end, who believe knowledge is first constructed internally and then externalized at one end and socio-culturists such as Vygotsky who believe that knowledge is first external and then internalized at the other. I situate my own perspective as being more closely aligned with that of Longino (1993) who argues that in order for the knower to be able to scrutinize knowledge claims he/she must use communal standards. In this view knowledge is actively "constructed not by individuals but by an interactive dialogic community"

(Longino, 1993, p. 112). Thus, one's development of conceptions of mathematics can be seen to involve both individual and social facets and it is to ideas of social learning that I now turn my attention.

Social Learning

The ways in which individual and social aspects of learning interact are described by Salomon and Perkins (1998) who identify several meanings of the term "social learning". Among these are two:

Social mediation as participatory knowledge construction – learning is seen less as socially facilitated acquisition of knowledge and skill and more as a matter of participation in a social process of knowledge construction.

and

Social mediation by cultural scaffolding – the learner enters into an intellectual partnership with cultural artifacts. These artifacts are culturally and historically situated. They form a learning system with the learner.

(Salomon & Perkins, 1998, pp. 3-6)

My interest in this study is the learning of individuals interacting within a collective social system, namely a mathematics classroom. My view then is of individuals in a mathematics classroom being both situated in a socio-cultural matrix and participatory in the construction of their own (and others') conceptions of mathematics and their own and others' selves. As Damon (1991) states, "Even when learning is fostered through processes of social communication, individual activity and reflection still play a critical role" (p. 392). My own position on how individual and social aspects interrelate is identified by Salomon and Perkins (1998) as a "*reciprocal spiral relationship*", i.e. "the two complement each other in a spiraling dynamic of reciprocal influences. Individual

and social causes become influenced by their own consequences and, sometimes, even defined by them” (p. 18). Boaler (1999) describes this situated perspective as “sufficiently broad and *nuanced* to inform the relationships formed between learners, their mathematical understanding and the environments in which they work” (p. 260).

In attempting, then, to understand how conceptions of mathematics develop or are influenced in classrooms, a situated, participatory socio-cultural perspective requires that *interactions* or the *relationships* between individuals, their social surroundings and cultural artifacts become the object of study. Studying such interactions from the socio-cultural perspective requires a widening of focus beyond behavior and practices to one in which communication is viewed as the medium in and from which conceptions of mathematics emerge.

What is Communicated via Mathematics Classroom Interactions

In the previous sections I have identified what I see as the goals for mathematics education, namely the fostering of a mathematical disposition and lifelong democratic access to powerful mathematical ideas, the achievement of which I argue depends in part on attending to non-cognitive aspects of mathematics teaching and learning. Next I outlined the epistemologies shaping these views and situated my own perspective in the socio-cultural domain. In this section I will look at what is communicated in mathematics classrooms when viewed from a situated, interactionist, socio-cultural perspective¹ and why these are important for achieving the goals described above.

¹ There are other ways to view what is communicated in mathematics classrooms such as Swanson’s (2005) socio-political perspective where, “...communication is not merely about “transmission” of mathematical ideas...it is a set of activities, interactions or practices which are socio-culturally and politically situated, and serve to produce, reproduce, or contest certain relations of power and control...” (p.262).

Apart from mathematical concepts and procedures students learn “how to interact in the classroom; ...particular sets of beliefs and practices and they learn the appropriate way to behave in the mathematics classroom. The different interactional patterns of the mathematics classroom do not accompany learning, they constitute their learning” (Boaler, 1999, pp. 264–265). In and through their interactions in a mathematics classroom students’ (and to some extent teachers’) beliefs, values, and attitudes towards mathematics and mathematics education are shaped (McLeod, 1992). These constructs, beliefs, attitudes and values are not easily separated (Bishop, Seah & Chin, 2003) and individuals themselves may not be able to articulate a distinction between their own beliefs, values, and attitudes. Furthermore beliefs, attitudes and values are thought to develop over prolonged periods of time (McLeod, 1992, Thompson, 1992). Thus the construct of ‘conceptions’ may be more utilitarian in studying classroom interactions’ influence on students and teachers.

According to Thompson (1992), “A teacher’s conception of the nature of mathematics may be viewed as that teacher’s conscious or subconscious beliefs, concepts, meanings, rules, mental images, and preferences concerning the discipline of mathematics” (p. 132). She goes further to argue that these conceptions influence the particular discursive practices of the teacher.

McLeod (1992) describes the relationship between beliefs, attitudes and emotions as “representing increasing levels of affective involvement, decreasing levels of cognitive involvement, increasing levels of intensity of response, and decreasing levels of response stability” (p. 579). Thus beliefs and attitudes are more cognitively oriented, tend to be more stable and develop over a longer period of time than emotions. However emotions are more likely to be a part of day-to-day interactions in mathematics classrooms.

In their work on values in mathematics education Bishop, Seah and Chin (2003) suggest that although values can be defined in terms of other affective variables, they “represent something much more significant or at a deeper level” (p. 723). They state that, “values in mathematics education represent one’s internalization, ‘cognitisation’ and decontextualisation of affective variables (such as beliefs and attitudes) in one’s socio-cultural context” (p. 734). Their view is of a recursive relationship between values, attitudes and beliefs where values derived from interests, attitudes and beliefs once internalized “subsequently foster the continual wider adoption of related attitudes and beliefs” (p. 725).

In studying classroom interaction over a relatively short period of time one is likely to encounter beliefs, attitudes, emotions and values in some form or stage of development. Given the recursive relatedness of these constructs, the stability of beliefs and values and the long term development of beliefs, attitudes and values, the overarching construct of ‘conceptions of mathematics’ may be more useful due to its ability to include all of these as they emerge in the course of interaction. Conceptions thus forms a more ‘fluid’ construct for conceptualizing how participants may interpret classroom interaction over the short term.

Students and Teachers’ Conceptions of Mathematics

In this section I will examine some of the literature that describes the conceptions that both students and teachers bring to mathematics classroom interaction and develop through such interaction. I will focus primarily on beliefs as they are described as “The Hidden Variable in mathematics education” (Leger, Pekkonen, & Torner, 2002).

Beliefs

At present, the construct belief is not well defined in the mathematics education research literature (Leger, Pehkonen, & Torner, 2002). Beliefs and knowledge are closely related, both being grounded in an individual's socio-cultural context. The difference is that the latter depends upon a truth condition, i.e. an agreement among members of a community that a certain proposition is true. Beliefs on the other hand, while socially grounded are individually validated and lack the same truth condition (McLeod, 1992; Op 'T Eynde, De Corte & Verschaffel, 2002). Despite the lack of conceptual clarity, the study of mathematics related beliefs is considered to be important in understanding the relationship between the cognitive, affective and conative aspects of mathematical problem-solving (Leger, Pehkonen & Torner, 2002).

Students' Beliefs.

A rich literature exists on the numerous beliefs that students have about mathematics (De Corte et al., 2000; McLeod, 1992; Schoenfeld, 1992). McLeod (1992), in his review of research on affect in mathematics education, proposed four categories of students' beliefs about mathematics. These are beliefs about mathematics as a domain, beliefs about the self as a mathematics learner, beliefs about mathematics teaching and beliefs about the social context. DeCorte et al. (2002), however, divide students' mathematical beliefs into three categories based on epistemological considerations in an attempt to provide a comprehensive framework "grounded in a theory of beliefs, rather than in a motivational or affective theory" (p. 303). Their categories are beliefs about the self in relation to mathematics, beliefs about mathematics education, and beliefs about the social context in which mathematical learning and problem-solving occur. The framework proposed by DeCorte et al. (2002) is a useful characterization as it partitions

mathematics related beliefs (MRBs) into those that are influenced largely by the individual, the domain itself or the (social) context. The framework admits some overlap between categories.

Students' beliefs about their perceived ability to understand and do mathematics (self-efficacy), their attribution for success or failure as well as their beliefs about the importance and usefulness of mathematics is thought to influence their activities during problem-solving activities (DeCorte et al., 2000; Mason & Scrivani, 2004; McLeod, 1992). For example, Pajares and Miller (1994) using path analysis found that self-efficacy was a better predictor of problem-solving than other variables such as math self-concept, perceived usefulness, prior experience or gender.

More recently, Tanner and Jones (2003) reported on a study carried out to investigate self-efficacy in mathematics and the use of self-regulated learning strategies during assessment events of 13 to 14 year old Welsh students. Their major finding was the existence of a substantial number of students whose beliefs would probably hinder their development of a healthy mathematical disposition. Such beliefs included attributing success and failure in mathematics to uncontrollable factors such as "luck with questions" (61%), "poor memory" (24%) or "having no natural ability" (14%). Their results also suggested that the majority of students do not revise appropriately and are thus unlikely to improve the regulation of their learning. The textbook played a significant role in student revision. For example 73% claimed to revise mathematics by reading through the textbook.

Students' beliefs about mathematics education are further partitioned by DeCorte et al. (2002) into three categories: beliefs about mathematics as a discipline; beliefs about mathematical learning and problem-solving and beliefs about mathematics teaching .

Schoenfeld (1992) lists some of these beliefs that students hold about the nature of mathematics:

Mathematics problems have one and only one right answer; There is only one correct way to solve any mathematics problem – usually the rule the teacher has most recently demonstrated; Ordinary students cannot expect to understand mathematics, they expect simply to memorize it and apply what they have learnt mechanically and without understanding; Mathematics is a solitary activity, done by individuals in isolation; Students who have understood the mathematics they have studied will be able to solve any assigned problem in five minutes or less; The mathematics learned in school has little or nothing to do with the real world; Formal proof is irrelevant to processes of discovery or invention. (p. 359)

Such wide-ranging and varied beliefs are inimical to the development of a healthy mathematical disposition and may reflect forms of socio-cultural conditioning. Teacher practices and instructional materials may do much to support this conditioning or at the least fail to challenge these beliefs. Schoenfeld (1988), for example, in a year long study of a tenth grade geometry class, found that although students were taught well and achievement scores were good, the students acquired beliefs about mathematics that would be considered antithetical to developing a healthy mathematical disposition.

Students' beliefs about mathematics and their subsequent behaviors are molded by their experiences inside and outside of the classroom and students hold beliefs about these contexts. With respect to the classroom, students hold beliefs about what constitute an acceptable solution or effective teacher, their role and the role of others in the classroom and how mathematics should be taught (DeCorte et al., 2002; McLeod, 1992). However DeCorte et al. (2002) note that

...there is little research that addresses these beliefs about the specific social context of the class, and how they relate to the more general beliefs... in order to fully understand the influence of mathematics-related beliefs on students' learning and problem-solving, it is necessary to focus on in future inquiry...[student] beliefs about the mathematics class context in which they have to perform. (p. 310)

Students' beliefs about themselves as mathematics learners and about mathematics exert a strong influence on their engagement with mathematics and their subsequent achievement. Such beliefs include confidence in one's ability (self-efficacy), perceived usefulness, attribution of success or failure, beliefs about mathematical behavior in specific contexts and beliefs about the nature of mathematics knowledge and problem-solving (De Corte et al., 2000).

In a meta-analytic review of 55 longitudinal studies that investigated the relation between self-beliefs (not restricted to mathematics) and academic achievement, Valentine, DuBois and Cooper (2004) found only a small overall effect size ($\beta = 0.08$) between self-beliefs and later achievement when initial achievement was controlled for. They thus concluded that though the effect is small, "among equally achieving students, having positive self-beliefs confers a small but noteworthy advantage on subsequent measures relative to students who exhibit less favorable self-beliefs" (p. 127). Larger effect sizes were found when the beliefs were related to a specific domain such as mathematics. For example, Ma and Kishor's (1997) meta-analytic review of the literature investigating the relationship between attitude towards mathematics (ATM) and achievement in mathematics (AIM) at elementary and secondary school levels found a small but significant (from zero) overall mean effect size of 0.12. More importantly though, their study revealed that the ATM-AIM relationship, while not strong at the elementary school level, strengthened by 79% from upper elementary grades to junior high grades but decreased by 20% from junior high grades to senior high grades. They concluded that junior high (or equivalently the early years of Secondary school) may be the most

important period for determining students' attitude to mathematics as it relates to their achievement in mathematics. Evidence that students' mathematics related beliefs tend to develop very early and remain fairly stable is supported by Kloosterman, Raymond and Emenaker's (1996) three year longitudinal study of elementary students' beliefs about knowing and doing mathematics.

A yearlong study by Turner, Thorpe and Meyer (1998) of 5th and 6th grade elementary mathematics students in Pennsylvania involved in challenging academic work found that negative affect after failure mediated self-efficacy beliefs. They concluded that such beliefs can detract from learning. Given the thrust towards more challenging mathematical work in reform curricula, negative affect is to be expected and thus understanding the role of negative affect in mediating MRBs is important in developing a sound mathematical disposition. Indeed, as McLeod (1992) cautioned, "If students are going to be active learners of mathematics who willingly attack non-routine problems, their affective responses to mathematics are going to be much more intense ..." (p. 575).

Taken together these studies suggest that not only are mathematics related beliefs important for later success but that it is important to help students to develop appropriate mathematics related beliefs from as early as possible and that the early years of secondary school may be the most important in this quest.

Teachers' Beliefs.

Teachers' mathematics related beliefs have been studied under the basic assumption that what teachers believe plays an important if not decisive role in "what gets taught, how it gets taught, and what gets learnt in the classroom" (Wilson & Cooney, 2002, p. 128). Thompson (1992), in her review of the literature, cites the following foci of research on teachers' beliefs: beliefs about mathematics, beliefs about mathematics

teaching and learning, or both. Since that time a significant body of evidence has accumulated regarding the importance of teachers' beliefs for enacting the curriculum (Wilson & Cooney, 2002; Lerman, 2002; Lloyd, 2002). Much of the research has been qualitative in nature involving case studies of a few teachers and focused on problems involved in changing teachers' beliefs. Furthermore, Wilson and Cooney (2002) note that studies of secondary school teachers' beliefs, "[have] placed little emphasis on the interplay between students' and teachers' beliefs..." (p. 133). This lacuna represents a serious deficit in our attempt to understand the development of healthy mathematical dispositions.

Handal (2003), in his review of the literature on teachers' mathematical beliefs, suggests that the educational system is a major factor in the reproduction of traditional maladaptive mathematical beliefs. He includes the lack of appropriate curriculum materials and the nature of textbooks as obstacles that prevent teachers, even those with appropriate belief systems, from fully implementing these beliefs in the classroom. Given the fairly fixed features of the educational system it thus becomes very difficult to change teachers' beliefs or practices in situ. For teachers he writes, "the relationship between [their] mathematical beliefs and their instructional practice is dialectical in nature and is mediated by many conflicting factors" (p. 54). Teachers' MRBs affect how lessons are organized, how they respond to students' work and how they interpret changes in policy and curriculum (Remillard & Bryans, 2004).

The Development of Mathematics Related Beliefs.

Given the importance of MRBs for mathematics achievement and engagement, and mediating reform initiatives, understanding the processes by which beliefs are acquired and persist is of critical concern (Pajares & Miller, 1994). According to

McLeod (1992) however, “there is nothing wrong with students’ mechanism for developing beliefs about mathematics; what needs to be changed is the curriculum (and beyond that the culture) that encourages such beliefs” (p. 579). This could be extended to include teachers’ beliefs as well. Thus McLeod’s challenge might be seen as a call for a change in the interactions and relationships (dialogues) of both students and teachers.

Significant evidence implicates traditional mathematics instruction as the main source of debilitating beliefs (DeCorte et al, 2003; Lampert, 1990). Lester (2002) adds another contextual factor: instructional materials such as textbooks, which may serve to reinforce such beliefs. That teachers’ beliefs do not always match their actual practice or students’ performance may be partially explained by poor pedagogical knowledge (Peterson et al., 1989) or weak domain specific knowledge (Borko et al., 1992, cited in Nathan & Koedinger, 2000). Relatively little attention has been paid to the potential role that socio-cultural artifacts play in the development of beliefs and affective responses of students and teachers.

Influence of textbooks & instructional materials.

Social learning also occurs by cultural scaffolding involving cultural artifacts (Salomon & Perkins, 1998). In traditional mathematics classrooms, the main socio-cultural artifacts are textbooks. Textbook usage by teachers and students form another layer of interactions that are implicated in the emergence and development of conceptions of mathematics. It is claimed that textbooks structure between 75% and 90% of classroom instruction in the United States (Tyson & Woodward, 1989). According to Robitaille and Travers (1992),

Teachers of mathematics in all countries rely heavily on textbooks in their day-to-day teaching... Teachers decide what to teach, how to teach it, and what sorts of

exercises to assign to their students largely on the basis of what is contained in the textbook authorized for the course. (p. 706)

Evidence that mathematics textbooks do influence how teachers teach is provided by Fan and Kaeley (1998) who compared the teaching strategies of 26 secondary school mathematics teachers from 13 different schools using traditional and non-traditional textbooks. Significant differences were found in the amount of time devoted to lecturing – almost twice as much in the traditional textbook classrooms as in the non-traditional classes, – and in the amount of time engaged in group work, – approximately five times that of the traditional textbook classes. Additionally, students with the non-traditional textbooks spent approximately five times as much time reading the text as their counterparts with the traditional texts. They concluded that not only do textbooks influence what is taught (content) but how it is taught (pedagogy).

Seah and Bishop (2000) in examining the values conveyed by eight representative mathematics textbooks from the first two years of secondary schools in Singapore and Victoria (Australia) found that both groups of texts emphasized the mathematical values of objectivism over rationalism, control over progress, and mystery over openness. They also found that the values of instrumental understanding were emphasized over relational understanding and specialism over accessibility among others. They suggest that the portrayal of mathematical values in these textbooks has the potential to influence young pupils' perceptions of mathematics.

While Seah and Bishop must be commended for drawing attention to the affective aspects of mathematics textbooks, their study failed to examine whether or not students actually acquire these values from the textbooks. Textbooks play a particular discursive role in the culture of most mathematics classroom. The questions that should be asked

are what do students come to value from their dialogues with textbook presentations of mathematics and what conceptions of mathematics do they develop?

Nathan and Koedinger (2000) propose that the content and organization of textbooks might be an important influence in shaping teachers' beliefs. Evidence for this, they suggest, comes from their study which examined the beliefs of 105 teachers. They showed that teachers viewed arithmetic development as preceding algebraic development and symbolic problem-solving as developing before verbal reasoning, mirroring their analyses of algebra textbooks and supporting what they term the symbol-precedence hypothesis. They suggest that, "It is reasonable to surmise that the use of textbooks in structuring daily classroom lessons, weekly assignments and year long curriculum sequencing leads teachers to internalize the images of mathematics they implicitly convey" (p. 228), and stress the importance of examining how this view emerges.

A later study by Nathan, Long and Alibali (2002) examined the rhetorical structure (the organizational sequence of problem-solving activities) of ten widely used pre-algebra and algebra textbooks. They found further evidence of the symbol precedence hypothesis especially among the algebra textbooks, mirroring their prior findings among high school teachers. This study demonstrates the importance of attending to widely used cultural artifacts whose structure and content may implicitly convey intuitive and appealing but maladaptive beliefs about mathematics.

It is important to determine how students and teachers interpret their interactions with the texts that they use and whether such interactions influence their conceptions of mathematics or mathematics education. Van Oers (2001) suggests that the development of mathematical attitude begins with "the teacher's demonstration of a specific type of behavior and, consequently, from her/his mathematics related *expectations* about the

pupils' activity" (p. 81). He goes on to suggest that "these expectations and the pupils' role of digesting these in action, play a significant role in the development of mathematics sense and attitude" (p. 81). According to Thompson (1992), "a question that has received virtually no attention from researchers on teachers' conceptions is the extent to which teachers' and students' conceptions interact during instruction (p. 141). Despite the volume of research on students and teachers' conceptions since that time Wilson and Cooney (2002) as well as De Corte et al. (2002) lament that the situation remains much the same.

Communicating Conceptions: Interactions in Mathematics Classrooms

Recent studies have begun to examine how classroom discourses influence students' conceptions of mathematics and their ability to achieve in mathematics (Amit & Fried, 2005; Ben-Yehuda, Lavy, Linchevski & Sfard, 2005; Harbaugh, 2005). Additionally classroom communication has come to take on a central role in mathematics education research (Alrø & Skovmose, 2003; Chronaki & Christiansen, 2005).

Amit and Fried (2005) for example, examined authority relations in two grade 8 mathematics classrooms as part of investigating how students conceive classroom practice and learning. Ten to fifteen consecutive lessons for each class were videotaped and students were interviewed after viewing and reacting to the videotape. They found that teachers, friends, parents or siblings formed a web of sources of help for students which appeared to have a hierarchical structure dependent on the degree of authority given to the sources. Among these teachers were seen as the central authority in the classroom. They describe some of the students' views of their mathematics teacher as "infallible", "a beneficent dictator" and a "creature of whim". Students also saw each other as authorities and a source of help. However, "when students [were] perceived by

their fellow students as knowing the answer to some question they [were] treated for that instant as an authority, that is, the answer [was] accepted and not discussed” (Amit & Fried, 2005, p. 159). These relations, they suggest, inhibit reflective thought. This study demonstrates that conceptions of mathematics (such as who is an authority) are developed not only by what teachers do but by the interactions of members of the mathematical community of the classroom.

Nathan and Knuth (2003) compared whole class discussions over two consecutive years of a 6th grade mathematics teacher, Ann. Their focus was on how a teacher’s beliefs about learning and instruction in mathematics influenced her practices and classroom interactions. Lessons were videotaped weekly and there were regular debriefing sessions. A multilevel analysis of the data was carried out “to document the classroom interactions in a more complete manner, and potentially identify more subtle forms of interaction” (Nathan & Knuth, 2003, p. 182). In the first year they found that students’ utterances addressed to each other accounted for roughly 1% of the total and most utterances were initiated by or directed to the teacher. In the second year Ann’s stated beliefs and goals did not change but her practices did as she adopted a less central role. Consequently, student initiated discourse increased to nearly 33%, and the global pattern of classroom interaction also changed dramatically. Despite satisfaction with this discourse pattern, Ann became concerned that students were not understanding the mathematical concepts. This study while dealing adequately with how a teacher’s conceptions influenced her actions fails to consider the calls made in the literature to analyze the ways in which teacher and student conceptions interact, i.e. how the discourse patterns are interpreted by the students as opposed to the teacher alone.

Mathematical Discourse: Interaction as Communication; Communication as Dialogue

Rationalist and empiricist epistemologies lead to a conception of knowledge as equivalent to true belief. From this perspective, learning is framed in terms of acquisition metaphors and teaching as communicating is viewed in terms of a transmission model. Participatory, situated socio-cultural perspectives, according to Sfard (2001) recast thinking, and thus learning, in terms of communicational models that differ from traditional transmission models. In these learning is viewed as becoming a participant in a discourse (Gee & Green, 1998; Sfard, 2001) as opposed to being a possessor of knowledge. This perspective views “all communicative and representational acts as forms of social practice...[and] explores discourses as forms of socio-historically constituted relations among people, activities, texts, and situations” (Burbules & Bruce, 2001, p. 1103). This perspective does not equate discourse with speech, though language is an important component of discourse analysis, but sees communication in a very broad sense (Burbules & Bruce, 2001, Sfard, 2001). Thus, all forms of interaction in the discourse practices of a mathematical classroom become viewable as communicative acts with the potential to influence participants’ (and observer’s) conceptions of the ongoing mathematical discourse.

According to Wagner (2004), “Language counts in mathematics education discourse because we have no direct access to the objects of mathematics; we can only access the language we use to point at these objects” (p. 12) and indeed research has focused on language use in mathematics classrooms (e.g. Pimm, 1987). However, as Wells (1999) points out, “language is not the only form of semiotic mediation...and the choice of medium significantly affects the outcome as well as the activity of thinking” (p.

141).² Further, he points to the fact that, “language learning cannot be separated from language use” (Wells, 1999, p. 144). Thus, while attention to the use of language in mathematical classroom discourses is important, in a situated, socio-cultural approach this cannot be the only focus. As Sfard (2001) argues, “[s]ince discourses are analyzed as acts of communicating, anything that goes into communication and influences its effectiveness – body movements, situational clues, interlocutors’ histories, etc. – must be included in the analysis” (p. 28). In order to determine which of these are attended to by participants in a mathematical discourse it is essential then to engage the participants in communicating their interpretations of how these events, acts, situations, and cues impinge on their engagement with the ongoing discourse and how these might be influencing how they view or are coming to view the mathematical discourse.

If all interaction in a mathematical discourse is potentially meaningful to the participants then there is the need to view discourse as being greater than the sum of individual exchanges. Indeed, individuals in a mathematics classroom are immersed in a discourse which is socio-culturally and historically situated. They are engaged in a polyphonic discourse with their teachers, their peers, their cultural resources, their schools, their families and themselves. Their participation in this discourse reflexively constitutes both the content of the discourse as well as its situated meaning(s). Bakhtin’s dialogic perspective provides a productive way of viewing mathematical discourse from a situated, participatory socio-cultural perspective.

² Goldwin-Meadow and Cook (in press) for example provides evidence for the importance of teacher gesture in improving the learning of mathematical equivalence among four year olds.

Dialogism³

Dialogism, according to Bakhtin scholar Holquist (1990), posits that “all meaning is relative in the sense that it comes about only as a result of the relation between two bodies occupying simultaneous but different space...”(p. 18). Indeed, whatever meaning is obtained from a dialogue “is shaped by the place from which it is perceived” (p. 21). A dialogic interaction for Bakhtin comprises a triad of utterance, reply and the relation between these. These relations and the meanings derived are always in a process of “being made or unmade” (Holquist, 1990, p. 29). This is in accord with the view of students and teachers’ conceptions of mathematics as interrelations born of utterance and reply subject to endless assessment and revision in the ongoing polylogical discourse that is a mathematics classroom. In dialogism, “something exists only if it means [and] anything that means is a sign, and since there is nothing that may not function as a sign, everything has the potential to mean” (Holquist, 1990, p. 49). However, this *meaning* is both internal as well as external since an individual both makes meaning for him/herself and provides signs by which others may derive meaning as well. In a mathematics classroom students and teachers may choose to attend to different dialogues in their construction of meaning. Thus studying dialogic interactions involves remaining open to the dialogues from which individuals choose to make meaning.

Burbules and Bruce (2001) in reviewing research on teaching as dialogue, argue for a constructive middle position between the extremes of all verbal interaction being

³ I acknowledge that Dialogism and dialogue are, as Linell (2005) describes them, ‘polysemous’ terms and that there are many forms of dialogue with varying concerns as Renshaw and van der Linden (2004) illustrate by drawing on Socrates, Freire and Bakhtin. However my focus is on a Bakhtinian understanding and application of Dialogism.

equated with dialogue and only specified forms as being true dialogue. They argue for a model of discourse,

that stresses a tripartite set of relations among discursive practices, other practices and activities, and mediating objects and texts...[in which] these relations...are not simply interactions among discrete social factors; they are dialectical relations among elements that mutually constitute one another...[and thus] any particular pattern of speech acts— such as dialogue— must be seen as situated in a complex net of interactions that govern how those speech acts are expressed, heard, interpreted, and responded to. In such a net of interactions, the full meaning and effects of discourse will be impossible to read off the surface meanings of the words themselves. (p. 1103)

Their model of discourse is essentially dialogical and leads them to call for research that moves beyond speech act analyses to how discourse shapes conceptions and responses (behavior).

Linell (2005) drawing on a number of dialogical scholars including Bakhtin, defines Dialogism more extensively as “a general epistemological framework for sociocultural (human) phenomena: semiosis, cognition, communication, discourse, consciousness, i.e. for the social, cultural and human(istic) sciences (and arts)” (p. 16). For Linell (2005) it is the way in which we “in different capacities and at different levels...acquire knowledge about the world and ascribe meaning to the world” (p. 5). Dialogism is the way we make meaning **in and from** the world. It circumscribes in a coherent and productive way the perspectives on situated sense-making through diverse semiotic mediators and constructive interactive sociocultural relationships.

The dialogical view of discourse in a mathematics classroom community opens up a conceptual space that is flexible enough to allow one to engage with the question of how participants’ conceptions of mathematics are influenced by the polyphonic discourse in which they are immersed and may help us to better understand how healthy mathematical dispositions might be fostered. The transitioning of students from primary

school to secondary school in Trinidad and Tobago involves movement from one mathematical community to another, from one discourse community to another. This transition, an important period for developing one's attitude to mathematics, may thus provide an important opportunity to understand how students' conceptions are shaped by their engagement with the polyphonic discourse of secondary school mathematics. The study of one's ideological and individual becoming, which might be viewed as developing conceptions and identity, is also addressed by Bakhtin (1981) in his essay *Discourse in the Novel*.

Britzman (1991) for example, draws on Bakhtin's scholarship in her critical study of learning to teach. In focusing on *becoming* a teacher she foregrounds Bakhtin's ideas regarding two types of ideological discourse that are always present in educational settings – *authoritative* and *internally persuasive* discourse. While acknowledging that discourse can *simultaneously* be both authoritative and internally persuasive Bakhtin suggests that they are usually dialogically opposed to one another, that there is struggle and that, “the dialogic interrelationship of these categories of ideological discourse are what usually determine the history of individual ideological consciousness” (Bakhtin, 1981, p. 342).

Authoritative Discourse

Authoritative discourse for Bakhtin is language and, by extension, the social practices which are engendered that are unitary in meaning, indivisible, temporally and hierarchically distanced from us, static, calcified, that resist representation, that demand allegiance, and whose authority is “indissolubly fused” to it. It is the word of the “religious, political, moral; the word of a father, of adults and of teachers...” (Bakhtin, 1981, p. 342). Since its authority in the past was already acknowledged, a past which

Bakhtin posits is “felt to be hierarchically higher” (p. 342) than the present, it is able to unquestioningly occupy a similarly elevated position. The language of authoritative discourse is not appropriated by the one perceiving it, rather it attempts to appropriate for its own purposes the allegiance of the perceiver. Though it may be conjoined with other discourses, it “does not merge with these; it remains sharply demarcated, compact and inert: it demands...not only quotation marks but a demarcation even more magisterial, a special script for instance” (p. 343). Authoritative discourse takes many forms in educational settings; several examples are given by Britzman (1991). However, what is of specific interest in this study is the mathematical discourse in a classroom part of which is likely to be authoritative.

Bakhtin (1981) writes,

Authoritative discourse cannot be represented – it is only transmitted. Its inertia, its semantic finiteness and calcification, the degree to which it is hard-edged, a thing in its own right, the impermissibility of any free stylistic development in relation to it – all this renders the artistic representation of authoritative discourse impossible...If completely deprived of its authority it becomes simply an object, a *relic*, a *thing*...there is no space around it to play in, no contradictory emotions – it is not surrounded by an agitated and cacophonous dialogic life, and the context around it dies, words dry up. (p. 344)

Authoritative discourse is premised on and posits a simple sender-receiver model of teaching and learning that is simplistic and problematic. It denies the existence and challenges of other social languages. To what extent is the dialogue in a mathematics classroom authoritative is one of the questions that this study seeks to examine.

Bakhtin also argues that methodologically mathematics and natural science are undialogized. He writes,

Mathematical and natural sciences do not acknowledge discourse as a subject in its own right. In scientific activity one must of course deal with another’s discourse...but all this remains a mere operational necessity and does not affect

the subject matter itself of the science, into whose composition the speaker and his discourse do not, of course enter. The entire methodological apparatus of the mathematical and natural sciences is directed towards mastery over *mute objects, brute things*, that do not reveal themselves in words, that do not *comment on themselves*. Acquiring knowledge here is not concerned with receiving and interpreting words or signs from the object itself under consideration. (Bakhtin, 1981, p. 351)

However while discourse continues to be largely unacknowledged within the practice of mathematics, the literature in this section suggests that this is not a completely accurate picture since discourse and language studies in mathematics education research have begun to be reported with increasing frequency. Indeed Harbough (2005) examines authoritative discourse from the Bakhtinian perspective in a case study of an eight grade Texas classroom. In this study he found a regular use of authoritative discursive devices by the teacher which he concludes served to position students at the lowest level of a mathematical authority hierarchy. His study though failed to acknowledge any internally persuasive elements of the discourse that he examines and reports on.

Internally Persuasive Discourse

Internally persuasive discourse, in contrast to authoritative discourse, is dynamic, uncertain, admitting plural and potentially contradictory meanings. It is heteroglossic and productive, giving rise to new meanings. However, it is “denied all privilege, backed up by no authority...and is frequently not even acknowledged in society...” (Bakhtin, 1981, p. 342). It is a marginalized discourse of possibilities. Internally persuasive discourse always entails a struggle with other internally persuasive discourses as it is engaged and attempts to interweave with our own words. In educational settings Britzman (1991) explains, “internally persuasive discourse provisions engagement with what we know and the struggle to extend, discard or keep it: it is characterized by those surprising questions

– raised by the students and the teacher – that move from exhausted predestinations to the unanticipated” (p. 21). In resisting the allegiance demanded by authoritative discourses, internally persuasive discourses are always in dialogue. This dialogue between internally persuasive discourses and authoritative discourses interanimates their relationship with the individual’s ideological becoming, occasioning not only the possibility of new meanings, but of “ever newer *ways to mean*” (Bakhtin, 1981, p. 346).

The mathematics education literature that I have dialogued with seems to be strangely silent on the matter of internally persuasive elements of mathematical and classroom discourses.

Summary

In this chapter I have described my theoretical perspectives which are grounded in a vision of democratic access for all to powerful mathematical ideas. I have also critiqued some of the relevant literature. I have endeavored to provide a reasoned justification for my choice of a dialogical approach to the question of examining the relationships between the polyphonic discourses of a mathematical community and the developing mathematical conceptions among members of the community. In moving from constructivist to socio-cultural concerns I have argued for the need to view mathematical discourse in terms of interactions, interactions as communicative relationships and such relationships as dialogue in a Bakhtinian sense (primarily).

In the following chapter I will report on the methodology I used to address my research questions. Specifically I used qualitative techniques to examine one class of beginning secondary school students’ and their teacher’s conceptions of mathematics along three dimensions following that of DeCorte et al. (2000, 2002). In my analytic chapters which follow I will discuss some features of the multiple discourses with which

individuals entered into an ongoing dialogue, and which contributed to their ideological becoming. In particular I will discuss some of the students' and their teacher's prior conceptions of mathematics as well as authoritative and internally persuasive elements of classroom dialogues that I observed and which were reported in research interviews.

CHAPTER 3

RESEARCHING DIALOGICALLY

Although I come from what I would consider a positivist oriented background in mathematics and science education, through my dialogues with the internally persuasive research discourses on situated socio-cultural perspectives on teaching and learning, some of which I discussed in the previous chapter, I came to appreciate that studying how “talk *builds* communities” in mathematics classrooms dialogically would require different methodological and analytic tools than that provided by the quantitative methods with which I would have been more at home.

Rationale for a Qualitative Inquiry

Qualitative inquiry shares four common concerns according to Edson (1988). These are sensitivity to context, research done in natural settings, holistic study of experience and an interpretative stance in attempting to explain the significance of experience. In attempting to address my research questions I cast the experiences of participants in a mathematics classroom as multiple dialogues. In this way I believed I could attend to the holistic experience of dialogue as the participants interpreted it within the context of a mathematics classroom.

The aim of qualitative research is to understand experience “as nearly as possible as its participants feel it or live it” (Sherman & Webb, 1988, p. 7). Given the recasting of experience as dialogue, such an understanding requires an acknowledgement that the researcher too becomes a contributor to and not merely an observer of the polylogical discourse of the systems that he studies. Thus, in attempting to understand dialogical relations in a mathematical classroom I view a qualitative stance as both necessary and appropriate.

This study is framed as an ethnographic case-study of the dialogical relations in a mathematics classroom.

Case Study

My unit of analysis for this study was a mathematical community defined as the different voices/discourses that occupied the same space at the same time on an ongoing basis. The space that I considered as my focus of study was delimited by the boundaries of the classroom and the time that was spent in dialogue with the other voices of this space. Consequently, the voices that made up the community in this study were restricted to the students, their teacher and socio-cultural artifacts used in the space and at the time, such as textbooks. Other voices which may have intersected with this community on occasion were noted though they were not considered as part of the ongoing dialogue with the community.

Case studies are important in producing context-dependent knowledge and Flyvbjerg (2004) notes that their generalizability can be improved through careful, strategic selection of cases. Their chief advantage is the ability to close in on real-life situations and generate dense narratives that may, “approach the complexities and contradictions of real life” (p. 430). Eysenck (1976, cited in Flyvbjerg, 2004) states, “sometimes we simply have to keep our eyes open and look carefully at individual cases – not in the hope of proving something, but rather in the hope of learning something” (p. 422).

Ethnography

LeCompte and Preissle (1993) frame ethnography as both process and product. The process of investigating the culture of groups of people and the product of reporting one’s findings form the boundaries of ethnographic research. It is concerned with

“enculturation and acculturation” (LeCompte & Preissle, 1993, p. 1). Its central assumption, according to Patton (2002) is that, “any human group of people interacting together for a period of time will evolve a culture” (p. 81). The observation, description and understanding of the culture of mathematics classrooms are ongoing fields of research within mathematics education (Seeger, Voigt & Waschescio, 1998). One of the aspects of this mathematics culture is the conceptions that the members of the community hold.

The characteristics of ethnographic studies include intimate interaction with participants, an accurate portrayal of their perspectives and behaviors, the utilization of inductive, interactive and recursive data collection and analytic strategies and the utilization of multiple data sources to examine “behavior and belief in context” (LeCompte & Schensul, 1999, p. 18). The usefulness of ethnography extends to studies of culture where the researcher is interested in what participants’ behavior means to them, the documenting of emergent processes and “answering questions that cannot be addressed with other methods or approaches” (LeCompte & Schensul, 1999, p. 30). Given my focus on the dialogical relations in a mathematics classroom, which I viewed as socio-culturally and historically situated, and their attendant effects on the development of students’ conceptions of mathematics, this approach allowed me the proximity needed to observe and gather relevant data.

Choosing the Site

Isabella Girls’ High School is a seven year government assisted secondary school in southern Trinidad. It is managed by a Christian denominational school board. There were several reasons for choosing this particular school. The first was that the school has an excellent record of achievement in school-leaving examinations including

mathematics as well as in extra-curricular mathematics competitions. Based on these facts there is intense competition to enter the school annually. Entrance to secondary schools in Trinidad and Tobago is governed primarily by performance in the Secondary Entrance Assessment examination (SEA). Consistently, several students entering the first form in this school are ranked in the first 100 students in the SEA. In this year 25 students (out of approximately 120) entering the first year (Form One) had been ranked in the first one hundred students. Thus, one of my assumptions in choosing this site was that all students entering into the first year had a desire to attend this school. Further, a second assumption underlying my choice of this school was that my own belief that students in the first year were likely to be motivated and thus more receptive to entering into an ongoing dialogue with an external researcher who was not a teacher or staff member at the school. My final reason for choosing the site is that the administration is generally supportive of the professional development of teachers and the school has participated in research studies in the past. I also have a professional relationship with members of the academic community there as I taught at a nearby school.

In selecting this school I was aware that it was probably atypical of secondary schools in Trinidad and Tobago. However, I viewed it as an extreme case in the sense of Flyvbjerg (2004), in that despite its uniqueness it was potentially information rich due to the engagement of more actors and mechanisms than other schools in Trinidad and Tobago in general. I believed that it offered the possibility of generating rich descriptions of mathematical dialogues as well as diverse conceptions of mathematics. Furthermore, in my opinion, the high motivation and prior achievement of students, the generally supportive and well intentioned staff members, the access to resources and the low incidence of disruptive student behaviors create an environment where the opportunity

for teacher and student engagement in dialogical interaction is enhanced. These are among the most desirable conditions for teaching and learning in Trinidad and Tobago.

Gaining Access & Building Rapport

One of the obstacles to successful ethnographic study is failure to attend to issues of trust namely, gaining and maintaining the trust of the participants (LeCompte & Schensul, 1999). Building rapport typically requires an extended period of time on-site and ‘living’ with participants in both case-study and ethnographic research (Eder & Fingerson, 2002). However, in this study I thought it better not to remain on site for a prolonged period of time. I explain my reasons for this below.

Given that this is an all girls’ High School with an all female academic and administrative staff I felt that the prolonged presence of a male researcher might alter the dynamic dialogue patterns. However, a period on-site I believed was essential to establishing a rapport between myself, the teacher and, her students. Thus I planned to be onsite for a period of approximately three weeks which I hoped would be sufficient time to allow me to accomplish this.

Before entering the site I spoke with the Principal via telephone. I succinctly described what my project was about, the resources I would require, the duration of time I would be on-site and the commitments required of participants. She gave verbal consent. A letter of information and consent form was mailed to the Principal.

Upon arriving on-site I met with the Principal for a brief meeting. The meeting was very cordial and the Principal was accommodating. The names of the Head of Department and the three mathematics teachers assigned to Form One that year were provided. It was also suggested that because the first day of school was given over to orientation activities that I should begin my dialogue in the classroom on the second day

of the term. This was acceptable to me. Before the start of the school year I met with the mathematics Head of Department and the three Form One teachers in the library to explain the purpose and nature of the research. I explained what I intended to do, how I planned to observe and record events and answered any questions pertaining to the study. I also described what their responsibilities would be if they decided to participate in this study. Of the three teachers one accepted the invitation to engage in ongoing dialogue, although she expressed some reservations and apprehension of having a camera in the classroom. I will describe the characteristics of this teacher in a later section.

Ideally, I was looking for a teacher who was familiar with technology, specifically e-mail, keen about communicating mathematics, with whom I would be comfortable working and who appeared to be comfortable talking openly with me about her professional practice. The only criterion that was not met was the familiarity with technology. The teacher had used e-mail before but did not currently have an active account. The teacher was provided with a letter of information, consent form and video consent form which she subsequently signed and returned to me.

The Head of Department expressed some reservations about the open-ended nature of the questionnaire and the quantity of writing it would require of students. She also suggested that students come into form one with conceptions, for example regarding equations, that they had to unlearn. In discussion with the teacher and the Head of Department it was suggested that I should not come into the classroom before Wednesday of the first week to allow the teacher some time to meet with the students and inform them about what would be occurring. However, I requested that the parental letters of information, consent forms and questionnaires be given to the students by the teacher on Tuesday with instructions that the questionnaires were to be completed by the end of the

week and that the consent forms should be returned as soon as possible. It was agreed that this would be done.

On the day before school began I telephoned the teacher of the class, Saraswati, to determine whether she still felt apprehensive about the project and to offer reassurances. She suggested that while she was more excited now about the project she admitted to feeling a little obligated since neither of the other teachers had agreed. I continued to reassure her that she remained in complete control of her class and could request that I leave at any point. We scheduled our first interview for the next day after she had met the class to gauge initial impressions and to hand over the research packages for students containing the questionnaire, letters of information and consent forms.

Entry into the Classroom

Prior to my coming into the classroom the teacher discussed with the students who I was, what I would be doing and how long I would be observing their classroom activities. She also gave out research packages and had received a number of consent forms back already. On Wednesday 7th September I entered the classroom with the teacher. I introduced myself and briefly described the nature of my research and answered a few questions from students. I observed and recorded classroom interactions on those days when the teacher was present.

Data Collection

Questionnaires

The two part questionnaire (Appendix B) was delivered to students by the teacher. The first part sought biographical and contact information. The second part consisted of sixteen free-response questions based on items used by Op't Eynde and De Corte (2003) and designed to elicit responses of students' experiences and conceptions of mathematics.

These included questions relating to conceptions of mathematics as a domain, conceptions about mathematics teaching, conceptions about mathematics learning and conceptions of the self in relation to mathematics. This was used to give an overall picture of the classroom at the beginning of the school year and contributed to my choice of which students were later considered to engage in ongoing dialogues. Specifically the questionnaires were used to determine level of familiarity with e-mail and chat programs as well as conceptions of mathematics along the dimensions mentioned above. At the end of the first week twenty-four questionnaires had been returned.

Video Recording of Dialogue in the Classroom:

Recording dialogue in the classroom is difficult. According to Burbules and Bruce (2001), “any particular study or account of discourse in the classroom will have to set some boundaries...for the factors that will be included as most significant” (p. 1104). As such the initial boundaries of what counted as dialogue in the classroom included teacher and student speech, teacher and student written text, teacher and student gesture and expression, and teacher and student interaction with instructional materials such as the textbook. These were chosen based on the recommendation of Pratt (1987) (cited in Burbules & Bruce, 2001) that, “at the point of contact among different forms of talking, the effects upon dialogue participants are strongest” (p. 1105). Therefore, I saw a need to focus on examining these dialogical boundaries between these different types of authoritative and internally persuasive discourses.

In order to capture the polylogue of the classroom I used a consumer grade digital video-camera with a mounted microphone. I chose not to use lapel microphones or other types of microphones because of the short period that I would be on-site and the potential for reactivity by both students and the teacher. I began video recording on my first day in

class since the majority of the students had returned the video-consent form signed in the affirmative. I had intended to use the first two days to determine the best position for the camera in terms of both audio and video quality. On the first day I placed the camera on the tripod in the front-left corner of the classroom and took up a position in the back of the classroom where I made field notes for the duration of the class. On review of the tape I saw that this position was severely affected by outdoor back lighting. On the next day I positioned the camera at the front right corner. However, after a short period of time I realized that it obstructed the exit and I moved it to the back right corner. This position proved to be satisfactory and for the majority of the time the camera was in this position where it was not affected by back light nor was it hindering the free movement of students or the teacher. An advantage of this position was that students' faces were for the large part not on camera, I could also record what was written on the black board and I could see whether students were deliberately looking at the camera. However, one disadvantage was that because students were frequently addressing the teacher, in some instances their voices were inaudible. This potential limitation was overcome by transcribing classroom observations before the next class and through the use of field notes when I felt that what the student had said was significant and might not have been recorded on the tape. Additionally an IC voice recorder was placed close to the teacher's desk to provide an audio backup in the result of video hardware failure.

Classroom observations were downloaded onto a laptop computer after the class. I was thus able to review the class and make notes of what I perceived to be interesting incidents during this process. Once downloaded, I transcribed the classroom dialogues. This offered me yet another opportunity to review the class, and dialogue with the data. Reviewing the classroom observations in this way also allowed me to begin the analytic

process by foregrounding certain aspects of the interactions and temporarily backgrounding others. Based on these transcripts I would decide which students I desired to dialogue with further, and formulate potential questions that could be asked of both the teacher and students. Over the three week period ten classes out of a maximum possible thirteen were observed and recorded. This generated approximately five and a half hours of video data.

Interviews

In order to understand how classroom dialogues were being interpreted by individual students and their teacher and how these were potentially informing their developing conceptions of mathematics, open-ended qualitative interviews were conducted during the three week period on-site. This allowed them to “give voice to their own interpretations” (Eder & Fingerson, 2002, p. 181). All interviews took place in the Student Services Room, a quiet, comfortable, well-lit, air-conditioned room which senior students used to study or relax in between classes. The room was next to one of the main arteries between the staff room and classes and thus was open to observation. On occasion this proved to be a minor distraction as the interviewees would turn to see who had come in the door, but this was not often.

In interviewing the students I would go to the class after reviewing the videotape and invite several of them to come as a group either at the recess or lunch break. Students were selected based on their questionnaire responses and consent forms as well as their contributions to previous classes. This, I believed, created a more natural and neutral setting than one-on-one, face-to-face interviews and would allow them to interact with their peers. The initial interviews were also about building rapport with the students and so questions related to their questionnaire were also asked. Interviews ranged in

length from five minutes to about 40 minutes depending on the amount of time that they could make available to me and within the boundaries set by the duration of the mid-morning recess and lunch breaks. Over the three weeks I conducted nine interviews involving sixteen different students. Some students who were invited opted not to attend the interviews. At other times students were engaged in other activities which prevented them from being interviewed at either recess or lunch time. I decided not to have interviews with students after school hours because of the possible inconvenience it might have placed on parents' schedules as well as the fact that I wanted to situate the research activity for students within the school day.

Students were asked prior to the start of the interview whether they objected to being video recorded. The camera was left on the table, I sat on one side of a simple desk with papers and the laptop on the table and the students sat on the opposite side. On several occasions we reviewed portions of lessons in order to refresh their memories of what had transpired in class or what they had said, before they were asked about the meaning or significance of these utterances. These interviews were also audio-recorded. These interviews generated approximately 2 hours and 12 minutes of video/audio data.

Interviews with the teacher also took place in the Student Services Room either in between classes or after school. Over the three week period six interviews with the teacher were conducted which ranged from about 6 minutes to about 40 minutes. These were aimed at building rapport and probing teacher interpretations of classroom dialogues. These interviews generated approximately one hour and fifty minutes of video/audio data. In one instance we reviewed portions of students' interviews while in another instance I read back the relevant portion of transcript.

Online Interactions

Prior to departing for Canada I invited four students to engage in online dialogues using an instant messenger program. Students were invited to e-mail at least once a week on what they thought were the most significant things that happened in their mathematics activities for the week. It was anticipated that this activity would not require more than two hours per week. Based on these responses an open-ended qualitative interview was to be conducted using an instant messenger program in the last week of every month in order to gain insight into their developing conceptions of mathematics. The content of e-mail messages were to serve as cues for the design of probes relating to dialogues in the classroom and conceptions of mathematics. These interviews were to be one-to-one and would last between 45 to 60 minutes. However, this aspect of the research design suffered setbacks. One student was unable to send her e-mails or to meet online, others e-mailed infrequently and online conversations depended on student's being already online. Towards the middle of the term electronic communications from the students waned and then ceased altogether. Upon later questioning students revealed that they had been occupied with class projects and consequently had been spending less time online. Because of the paucity of data from this segment I have decided not to analyze any of these electronic contributions in this thesis.

Multiple Methods & Triangulation

In studying something as rich and diverse as dialogue in a complex setting like a mathematics classroom, multiple methods should be employed (Burbules & Bruce, 2001). Eder and Fingerson (2002) state that, "combining methods is often useful in research because it is difficult for any single method to capture fully the richness of human experience" (p. 188). In ethnographic research participant observation is frequently

combined with interviews (Eder & Fingerson, 2002; LeCompte & Preissle, 1993; LeCompte & Schensul, 1999; Patton, 2002). In this study the combination of different types of data, questionnaire, interview and observation, allowed for cross-validity checking (Patton, 2002).

Rationale and Description of Discourse Analysis

In studying how conceptions of mathematics are shaped dialogically from an ethnographic perspective I required an analytic framework that would allow me to understand participants' own meanings as described in their own words and by their actions. Discourse analysis provided such an analytical framework. According to Gee and Green (1998),

Discourse analysis,...when guided by an ethnographic perspective, forms a basis for identifying what members of a social group need to know, produce, predict, interpret, and evaluate in a given setting or social group to participate appropriately and, through that participation, learn. Thus an ethnographic perspective provides a conceptual approach for analyzing discourse data from an emic (insider's) perspective and for examining how discourse shapes both what is available to be learned and what is in fact learned. (p. 126)

The aim of discourse analysis, according to Potter (2004) is, "to make visible the ways in which discourse is central to action, [and] the ways it is used to constitute events, settings and identities..."(p. 9). He identifies three fundamental principles of discourse analysis: that discourse is viewed as action-oriented, situated and constructed. The first principle, that discourse is action oriented, draws attention to the activity of discourse, "It is about unpacking and rendering visible the business of talk" (Potter, 2004, p. 609). What discourse is doing and how it does it are the main questions here. The second principle, that discourse is situated, acknowledges that, "actions do not hang in space but are responses to other actions, and they in turn set the environment for new actions"

(Potter, 2004, p. 609). The third principle, discourse is constructed, refers to both the constituents of discourse (words, idioms, rhetorical devices) and the way discourse “constructs and stabilizes versions of the world” (Potter, 2004, p. 610).

In addition to Potter’s (2004) work, Gee (2004) explains that the goal of Discourse analysis is to “render even Discourses with which we are familiar “strange”...” (p. 102). He highlights that an important aspect of discourse analysis is examining the ways and means by which social situations create and are re-created by institutions such as schools or even individual subject matter disciplines. In order to achieve this, the discourse analyst asks questions about how language in a specific social situation is used to “build” things. For Gee (2004) there are seven building tasks which language is used to enact. These are significance, activities, identities, relationships, politics, connections and sign systems. In order to study how these tasks “work” in situations the analyst uses several *tools of inquiry* including Social languages and Discourses.

Social languages are styles of language employed by a particular group or for a particular purpose. They are used to “express different socially significant identities and enact different socially meaningful activities” (Gee, 2004, p. 35). **Discourses** are “ways of combining and integrating language, actions, interactions, ways of thinking, believing, valuing and using various symbols, tools, and objects to enact a particular sort of socially recognizable identity” (Gee, 2004, p. 21). It is in the social languages that clues to the way the building tasks are achieved are to be found. Two further tools are also introduced by Gee (2004). These are situated meanings and discourse models.

Situated meanings are those meanings that we assemble in the process of communicating in a given context. Further they are “flexibly transformable patterns that come out of experience and in turn, construct experience as meaningful in certain ways

and not others” (Gee, 2004, p. 67). **Discourse models** are “simplified, often unconscious and taken-for granted, theories about how the world works” (Gee, 2004, p. 74).

Discourse models help to explain why certain words mean what they do in a given situation or among a given social group. For Gee (2004), “Discourse models can be about “appropriate” attitudes, viewpoints, beliefs and values; “appropriate” ways of acting, interacting, participating, and participant structures; “appropriate” ways of talking, listening, writing, reading, and communicating; “appropriate” ways to feel or display emotion...” (p. 83).

The building tasks and the tools of inquiry suggested by Gee (2004) provided a suitable analytical framework in which to study the relationships enacted in the specific social situation of a mathematics classroom via the talk and texts of the participants as they constructed conceptions of mathematics.

Finally, Gee (2004) notes that one of the central principles of analyzing discourse is that,

We always assume, until absolutely proven otherwise, that everyone has ‘good reasons’ and makes ‘deep sense’ in terms of their own socio-culturally specific ways of talking, listening, acting, interacting, valuing, believing, and feeling...we are all members of multiple Discourses and so the analytic task is often finding which of these, and with what blends, are operative in the communication. The assumption of ‘good reasons’ and ‘deep sense’ is foundational to discourse analysis. (p. 93)

These principles and tools of inquiry of discourse analysis guided my reading, interpretation and analysis of the dialogue/polylogue in the classroom.

Method of Data Analysis

Analysis of the data began during the process of data collection and recording. As a participant in the dialogue of the class, since my presence there itself was a sign, I too

began to derive my own situated meanings from the utterances (and silences) of the participants. However, as I looked at the video records and transcribed the data or typed in the questionnaire responses I began to ask (myself) questions about the meaning of the ideas and words that they had used and how they might be interpreting the things that I had seen and heard. I made a note of individuals who I would like to interview as well as questions that I would like to ask. Before the interviews I would revise these questions in to what I hoped would be an accessible form for students.

Data analysis proceeded in a recursive fashion in that questions arising from classroom observations or interviews were used to design probes for interviews. Responses from interviews with one group of students were followed up with other groups as well as the teacher. Data recording, transcription and analysis proceeded sequentially and recursively (Patton, 2002).

Analysis of Student and Teacher Questionnaires.

Student responses to the questionnaire were tabulated by individual question. These responses were then grouped into categories consisting of two or more questions that either had been previously related to one of the themes being examined or had elicited similar responses. Four categories were initially defined; these were, mathematics as a domain, the self in relation to mathematics, learning and doing mathematics and mathematics teaching.

For each question a number of themes were identified based on the students' responses. For each category cross questions themes were identified. In order to represent the diversity as well as similarity among student responses in each category I decided to represent this information as concept maps. This enabled me to visualize some of the classroom discourses and conceptions at the beginning of the school year and

contributed to my choice of students for engagement in the term long online dialogue.

Additionally, the questionnaires were used to determine the level of familiarity with e-mail and chat programs as well as conceptions of mathematics along the three dimensions. The questionnaires contributed to addressing directly the question of “What conceptions of mathematics do participants in the mathematical community of a beginning secondary school classroom initially bring to the discourse?”

Saraswati was unable to complete her questionnaire and so it was agreed that we would go through the questions verbally during our final interview. This portion of the interview was transcribed verbatim and analyzed in a similar fashion to the students’ questionnaires by locating themes.

Analysis of Observed Classroom Dialogues and Field Notes.

Video recordings of class activities were transcribed in a two step process. While on-site, I was able to view the recording twice – once when it was being downloaded and once for transcription. In the transcription on-site I referred to my field notes to determine which individual segments of classes to transcribe verbatim. Other incidents were loosely transcribed. Lessons were divided roughly into segments which corresponded to the main activity taking place at the time, for example reading the textbook or correcting homework.

Once off-site I returned to these video-recordings and completed the full transcription using my field notes. Every audible utterance was recorded. Each lesson was divided into segments as described above and the duration of each segment was expressed as a percentage of the total class time. Utterances were coded identifying the source(s), the intended audience(s) and the direction of the utterance. I did not examine the actual temporal length of utterances since I felt that this was moving away from my

focus on the meanings that participants made from the dialogue. I have chosen to represent this information in the form of an arrow diagram which allowed me to identify patterns of interaction across classes. This directly (though partially) addressed the question “What are the major discourse patterns in a beginning secondary school mathematics classroom?” “Who are the primary voices in these discourses?” and “What are they saying (explicitly or implicitly)?”

Specifically, I looked at the nature of the interactions, namely the amount of time spent talking, reading, listening or in other activities by the participants in dialogue, the frequency of each of these different types of interactions and how the utterances and responses were directed. These were teacher to class, teacher to student, student to class, student to student, teacher to text, student to text or other. These interactions were also analyzed for their mathematical and social content as they might relate to the three dimensions of conceptions of mathematics identified previously. Critical incidents within lessons were identified.

According to Eder and Fingerson (2002), a sociolinguistic approach can “strengthen the validity of interviews as well as complement other modes of data analysis by showing how certain beliefs are acquired and communicated” (p. 182). This type of analysis was useful for this study which attempted to understand the links between dialogue(s) and conceptions. One way to do this is through “bracketing” in that what is being said is analyzed separately from how it is being said. Alternatively, both can be organized around content. I chose the latter approach.

Analysis of Interviews and Electronic Dialogues

A number of student and teacher interviews were done on-site in order to address the following questions, namely, “How are these voices/discourses interpreted by the

members of the mathematical community?” “How do the discourse patterns interact with one another?” and, “Do these patterns influence the conceptions of mathematics that the participants in the ongoing discourse hold or come to hold?” Again, interviews were transcribed verbatim, critical incidents identified, themes relating to conceptions of mathematics as a domain, the self, mathematics teaching and learning as well as emergent themes were examined. These were directed at looking for changes in mathematical conceptions or stability of such conceptions and how these relate to the ongoing discourses between teachers, students and text.

As mentioned previously, there was a paucity of online data and so no analysis of those transcripts was performed.

Reporting the Analysis

After completing the process of transcription, coding and analysis I faced the task of how to organize the mass of data and analytic findings into a coherent picture that simultaneously addressed my research questions as well as my concern for what I had observed. In Chapters 6 through 8 I have presented my analytic findings with some discussion. I have organized the analysis in a way that seems most productive for me and illustrative of the tensions and possibilities that existed in the classroom over the research period. In Chapter 6 I report on students’ and their teacher’s prior discourse models of mathematics. In Chapter 7 I examine some elements of the discourse that I perceived to be authoritative in nature and in Chapter 8 I suggest what I consider to be some internally persuasive elements of the discourse that were important for individuals’ becoming. Throughout I have chosen to allow individual’s voices to speak for themselves in the many transcripts, though I do provide my interpretation of some of these utterances.

In order to protect the confidentiality of the participants, pseudonyms have been

used for the teacher, students and the school. In addition, digital video tapes were erased after an archival DVD copy was made of the classroom observations and interviews.

Preliminary drafts and rough material in which actual names appear have been shredded and remain in my possession together with all original transcripts.

Efforts to enhance Trustworthiness

Moschkovich and Brenner (2000) identify four dimensions that could be considered important in improving the trustworthiness of naturalistic research. These are truth value, applicability, consistency and neutrality.

Truth value refers to the degree to which the results are able to capture what is occurring in terms of the constructs used by the participants themselves. The strategies recommended to improve the truth value of research are prolonged engagement, persistent observation, triangulation and member checking (Moschkovich & Brenner, 2000). Although there was not prolonged engagement due to the premature termination of the online component of the study, I do not feel that persistent observation by this researcher in the setting described was appropriate for the reasons outlined previously. Triangulation in the form of multiple viewpoints, textual analysis and observation all contribute to the truth value of this study. Given the potential richness of dialogues in a mathematics class I feel that the decision to use video to record dialogues was warranted despite the potential for reactivity. Additionally, the use of e-mail and chat programs was intended to create an automatic audit trail to which both the participants and myself would have had access.

Reactivity refers to ways in which the presence of an observer influences the activities of participants (Patton, 2002). I have described several ways in which I attempted to minimize reactivity. These included a period of acclimatization, removal to

an off-site location, limited use of video recording and the use of a reflective journal and audit trail. Patton (2002) and LeCompte and Preissle (1993) both recommend the use of a reflective journal by the researcher to identify and record possible sources of reactivity during field observation. An audit trail is a record of decisions made throughout the process of data collection and analysis. By itself it is of limited use in “identifying or justifying actual shortcomings that have impaired reliability and validity” (Morse, Barrett, Mayan, Olson & Spiers, 2002, p. 7). However, combined with field notes, the raw data, and a reflective journal, it can help both the researcher and the evaluator of research to understand rationales behind decisions and the responsiveness of the researcher to the data (Morse et al., 2002).

Applicability refers to the degree of relevance that the results have for other contexts. Strategies concerned with increasing applicability include thick description of the context and its dynamics as well as purposeful sampling (Moschkovich & Brenner, 2000). The on-site observations and the ongoing interviews with students provided the thick descriptions while my choice of students and teacher was done to maximize potential information. This study does not aim to generalize beyond this context but to create a greater awareness of the dialogues in a classroom.

Consistency refers to the likelihood that similar results could have been obtained under similar circumstances. Here, Moschkovich and Brenner (2000) recommend the construction of an audit trail that allows others to reconstruct and critique the choices made and the use of recording devices. Neutrality refers to the way in which researcher biases are dealt with as the research program unfolds (Moschkovich & Brenner, 2000). Here the audit trail is essential in allowing others to understand the choices I have made.

Validity in Discourse Analysis

Gee (2004) argues that validity for a discourse analysis is never “once and for all” but that like language itself, it is always open to further dialogization. However, he suggests four criteria by which a discourse analysis is judged to be more rather than less valid. A discourse analysis becomes more valid the more the answers to different questions raised by using the different tools of inquiry to understand the building tasks *converge*. Secondly, a discourse analysis is more valid the more “ ‘native speakers’...and ‘members’ of the Discourses implicated in the data *agree* that the analysis reflects how such social languages actually function in such settings” (p. 113). Finally, a discourse analysis is more valid the more it is tied to actual *linguistic details*. Like the languages that it studies, reports on and uses, validity for a discourse analysis is “social, not individual” (p. 114). As a final ethical principle of conducting discourse analysis Gee (2004) stresses the importance of the researcher openly acknowledging any information that contradicts the tentative conclusions.

Researcher Responsiveness.

Finally, Morse et al. (2002) draw attention to the critical importance of researcher responsiveness in the quality of qualitative research. They state,

Research is only as good as the investigator. It is the researcher’s creativity, sensitivity, flexibility and skill in using the verification strategies that determines the reliability and validity of the evolving study...[and] The lack of responsiveness of the investigator at all stages of the research process is the greatest hidden threat to validity...” (Morse et al., 2002, pp. 10–11)

Throughout this study I have attempted to be responsive to who was speaking, what they were saying, how I was analyzing it, the way in which I chose to present the data and analysis and the meanings that I derived. In the end, however, I acknowledge fully that the responsibility for the quality of qualitative research ultimately rests with myself.

CHAPTER 4

SOCIO-HISTORICAL CONTEXTS

The purpose of this chapter is to provide my understanding of the social and historical contexts in which the research was conducted. It will describe some of the D/discourses operating within the research context. Its purpose is to provide a background against which the analytic sections should be read.

Trinidad and Tobago

Trinidad and Tobago is a twin island Republic at the southernmost end of the Caribbean archipelago, north-east of Venezuela. The islands have been inhabited in the past by Amerindians, and colonized by the Spanish and the British. During these waves of colonial rule the indigenous populations were decimated. In addition, other Europeans such as French settlers arrived and settled here. Africans slaves were brought, followed by East Indian indentured laborers, to serve on agricultural estates. Other groups such as Chinese and Syrians arrived over the course of its history as well. Today the country describes itself as cosmopolitan with an ethnic make up of approximately 40% of East Indian heritage, 40% African and the remainder split among minority groups and a substantial mixed population. Christians, Hindus and Muslims make up a significant part of the population. Trinidad is often described as a multicultural society.

Until fairly recently, however, the mathematics curriculum was dominated by what might be called a Eurocentric view of mathematics. This is exemplified in terminal examinations which are modeled after the English school-leaving-examinations and pedagogy that is aimed primarily at helping students to pass examinations. In this situation, mathematics education often seems to divorce mathematics from its socio-historical roots resulting in a homogenously unpalatable discipline. Such is the enduring

legacy of colonialism. In this situation, Trinidad and Tobago, like other small countries in an increasingly smaller world, is concerned about the mathematical competence of its population given high failure rates in terminal examinations and a pervasive attitude among the population that while mathematics is important it cannot be done by most people. Indeed, as the mathematics syllabus itself states,

Reports from external examination bodies, the Ministry of Education, employers and public and private agencies on mathematical achievement, have all concluded that the majority of our students at the primary and secondary levels lack basic skills in numeracy. The high percentage of students who are not certified as being proficient in mathematics is an indicator to the Ministry of Education that there is a problem. (Republic of Trinidad & Tobago Ministry of Education, 2001, Section 2-2)

Isabella Girls' High School

I chose to conduct my research at Isabella Girls' High School in southern Trinidad for a number of reasons, outlined in the previous chapter. The school has a strong tradition of academic as well as co-curricular excellence and consequently, it is among one of the most competitive to gain entry to in southern Trinidad. Entrance to secondary schools in Trinidad is governed by students' performance on the Secondary Entrance Assessment examination (SEA). In the 2005-2006 academic year, 25 out of the approximately 120 students entering Form One were ranked in the 'top hundred' of students who wrote the exam (roughly the 99th percentile and higher). During their first weeks at this institution these students were often required to attend award and recognition functions hosted by the Ministry of Education or other bodies. On my first day in the classroom a number of students were absent for this reason. Thus, there is already operating here several related Discourses regarding success, academic accomplishment, reward, recognition and hierarchies of authority.

The school seems to take seriously its responsibility for the development and welfare of its staff and students. During my period on-site a new wing was being built to accommodate additional classes and a number of classrooms had been recently air-conditioned. There was also a staff 'breakfast' meeting and departmental meetings at which the 'curriculum' was discussed. As an example of its organization and preparedness, in the second week of the term the school was evacuated as part of the school's emergency procedures. Teachers and students clearly knew their roles and performed them with remarkable precision. This was timely given a recent spate of disruptive bombings in the capital city and prank calls to schools. Indeed at the end of the next week familiarity with this procedure would be needed as students and faculty had to be evacuated as a result of such a bomb threat.

The Form One classrooms are organized traditionally with a single chalkboard at the front of a room containing 40 singleton desks and chairs arranged in dyads and all facing the chalkboard (Figure 4.1). This arrangement too is part of an authoritative discourse (Gee, 2004) which delineates and designates the person speaking from the front of the classroom, addressing the other members, as a member of a particular social group, a teacher. The teacher's desk faces the class and is to the left of the chalkboard when viewed from the students' point of view. There are ample aisles that allow for student and teacher movement around the classroom. Classes are approximately 35 minutes in duration and there are eight periods per day. Each period is usually devoted to a different academic subject. Students have a period of mathematics every day.

Isabella Girls' High School is a government assisted secondary school; it is managed by a denominational board of management and is allowed some latitude in the

Figure 4.1: Classroom layout.



interviewing and hiring of staff. There were no male members of the teaching or administrative staff during my period on-site. Saraswati, the teacher in this study, was hired through such an interview process three years earlier.

Saraswati

Saraswati is a pleasant young woman, recently married, in her mid twenties, of mixed descent who has been teaching for five years after graduating from the University of the West Indies with a degree in mathematics and physics. She teaches both subjects at the secondary level. Prior to teaching at Isabella Girls' High School she taught at a high school for remedial students in the capital city. As part of her preparation to teach in the remedial school she had attended short workshop sessions in the vacation period prior to the start of the school year. This seemed to be her only formal exposure to teacher preparation as she has not yet taken the in-service Diploma in Education. As mentioned previously, this is not uncommon among secondary school teachers in Trinidad and Tobago.

At the beginning of the study Saraswati was very apprehensive about being “looked at” and “evaluated” by others and of having someone else in her classroom. Clinical supervision and team teaching are not widespread norms in classrooms in

Trinidad and Tobago. She acceded to becoming a participant, however, seemingly out of a sense of duty and a commitment to her own professional development. She seemed to implicitly agree with her head of department that it would be good preparation for the Diploma in Education. After the first few days her apprehension lessened and she appeared to be quite comfortable with my being in her class. In our interviews Saraswati seemed to be very open, at ease, and honest. Although accommodating, she would inform me in advance when she would not be able to make our scheduled interview session and we would negotiate another time which was convenient for her. Additionally, she communicated very clearly to me that she would prefer the first few days to get to know the class, a wish that I respected. Isabella Girls' High School is very much like the secondary school that Saraswati herself attended. They are both single-sex government assisted schools run by (different) denominational boards of management.

In the next Chapter I discuss Saraswati's conceptions of mathematics and, indeed, of herself. However, the portrait above is meant to provide an outline of some of the prior Discourses from which Saraswati emerged and in which she is enmeshed.

Students

There were 39 students in Form 1N in this academic year. Seven of them had placed in the top hundred of the SEA, with the highest being ranked eleventh. Students came from a number of different primary schools located in southern Trinidad, professed a variety of religious beliefs and represented a number of different ethnicities reflecting Trinidad's cosmopolitan nature.

Some students were more outspoken than others and contributed to the classroom discussions more than others. Students in general did not seem apprehensive about asking questions of their teacher when they did not understand. In choosing students to

be interviewed and for the online portion of this investigation their ranks in the SEA examination were not considered. Rather their outspokenness or actions in class as they seemed to contribute to the classroom dialogue were the major determining factors (together with consent forms).

Placing among the top one hundred of students writing the examination seemed to be a significant event for some of the students in this study and was referred to by the students themselves and by their teacher on several occasions. For some of the students it appeared to be a badge of honor, a mark of distinction, a 'set-apartedness', a just reward for sacrifice and hard work; for others it did not appear to outwardly concern them. This experience, of writing the SEA examination and being admitted to their 'first-choice' school then is a common social language for all of them.

Secondary Entrance Assessment Examination (SEA)

The Secondary Entrance Assessment Examination (SEA) replaced the Common Entrance (CE) examination for admission to secondary schools in Trinidad and Tobago. The examination consists of mathematical reasoning and verbal/literacy tasks.⁴ The examination plays a significant role in determining which secondary school, students are able to attend. There is intense competition among students to secure places at government assisted secondary schools like Isabella Girls' High School because of the prevailing belief that these schools offer greater opportunities to students.

As a result of the competition to secure places at 'prestigious' secondary schools, pressure to succeed is often placed on students by themselves, their families and their primary schools. Examination stress is common among students writing this exam and

⁴ The SEA exam will be modified to include a Science component from 2007.

feelings of relief, joy, exultation, sadness and disappointment typically accompany the annual release of results.

The SEA exam and issues associated with it form a complex Discourse with a capital D (Gee, 2004) in Trinidadian society. I will not address this issue directly at this time. However it is important to recognize that the SEA Discourse is a powerful influence on the development of students' conceptions regarding teaching, learning and educational achievement in general and, as it relates to this study, mathematics in particular.

Secondary Education Modernization Programme (SEMP)

As part of its efforts to reform and improve the curriculum content and delivery in secondary schools a program of restructuring and modernization, the Secondary Education Modernization Program (SEMP), began in 1999 (Republic of Trinidad and Tobago Ministry of Education, 2004). As part of this program a comprehensive review of secondary syllabuses was undertaken and a core curriculum of eight subjects decided upon. Mathematics forms part of the core curriculum. New mathematics syllabuses have been prepared and delivered to schools for implementation in forms one to three. The syllabus states that "Goals are desired expectations. They are statements of intent, that is, what one sets out to achieve", and goes on to list the following goals:

- To make mathematics relevant to the interests and experiences of the students and to prepare students for the use of mathematics in further studies
- To cultivate creativity and critical thinking in applying mathematical knowledge and concepts to solve routine and non-routine problems
- To develop skills in inquiry by the use of mathematics to explain phenomena, and by recognition of the influence of mathematics in the advancement of civilization
- To promote appreciation of the role of mathematics in the aesthetics and to make mathematics fun
- To encourage collaboration among students and to promote positive attitudes and values in students through the completion of mathematical tasks

- To provide opportunities for students to experience the structure of mathematics and to appreciate the elegance and power of mathematics
- To provide students with a range of knowledge, skills and techniques relating to number, geometry (space and shape), algebra, measurement, relations, functions, and statistics in a manner relevant to the technological advancements of the 21st century.

(Republic of Trinidad & Tobago Ministry of Education, 2001, Section 2:3)

The discourse associated with the SEMP is student/learner centered and professes a self-actualization curriculum orientation. With respect to mathematics the syllabus describes it as “the study of the properties of number and its relation to measurement, space, shape, statistics and probability. Mathematics is essentially an abstract subject, and algebra is in essence the strand of mathematics that presents this in its purest form” (Republic of Trinidad & Tobago Ministry of Education, 2001, Section 2-2). This presents a view of mathematics that is closely aligned with and privileges one particular domain of mathematical expression, namely formalism, as presented in algebraic terms.

The Secondary Education Modernization Program is presently undergoing various stages of implementation in secondary schools throughout Trinidad and Tobago. Further information regarding the philosophy, rationale and objectives of the SEMP mathematics syllabus are included in Appendix C.

Textbook.

In Trinidad and Tobago textbooks are currently provided as a loan to students for the academic year by the government under the SEMP program. Schools are required to select texts from a list of approved resources provided by the Ministry of Education. The mathematics textbook that was being used this year was *Mathematics for Caribbean Schools: Book 1*, second edition by A.A. Foster and T. Tomlinson (1998). It was also used in the previous year and has been used in Trinidadian High Schools for a number of

years. The text has not been re-written in light of the recent adoption of the SEMP syllabus.

Summary

This chapter sought to delineate some important and relevant features and D/discourses of the socio-cultural and historical context in which the research was conducted. These features include an understanding of the history, demography and education system of Trinidad and Tobago in general. In addition I have attempted to provide background information on the specific school, teacher and students involved in this study.

In the next chapter I provide a chronological overview of the entire research project as it unfolded.

CHAPTER 5

CHRONOLOGICAL OVERVIEW OF RESEARCH

In the analytic chapters which follow this one, events are not always related chronologically. Thus, I think it is important to have an idea of how the research project unfolded – of the utterances and replies as they occurred sequentially. This will help to situate critical incidents in their historical context in terms of events that preceded and succeeded them. In this section I provide such an overview.

I have chosen to present this overview in tabular format as opposed to a narrative as many of the incidents are developed in detail at the level of actual utterances and interactions in the following chapters. The tables report on what occurred during interviews with the teacher (T.I.), students (S.I.) and what I observed in the classroom (C.O.). The final column points to a later section where the specific incident or utterance is developed further.

Table 5.1

Overview of first week

Event	Significant events/utterances	Discussed
<i>Monday September 05, 2005</i>		
T.I.1	<ul style="list-style-type: none"> - This brief conversation was meant to familiarize Saraswati with the interview process and to ascertain her first impressions of the class. - She described them as being quiet, anxious, excited, scared and nice. - She hoped to be able to complete the syllabus with them by the end of the year. - Additionally she wanted students to understand mathematical concepts. - She described being scared to meet the class and wondered whether they would like her. 	<p>Saraswati's teaching goals, p. 140.</p> <p>Mathematics teaching, p. 137.</p>

Wednesday September 07 2005

- C.O.1 - Class began by correcting a homework exercise. The teacher would read the entire question and the student would then stand and recite her answer from her notebook.
- The teacher then directed the class into a brief revision of the previous day's work- base ten and the number of symbols in base ten.
 - Saraswati then demonstrated the place value system for base two. After which Marian asked why 'two to the power of zero was one'. The teacher's response was that it's a law or rule in mathematics and suggested that they make a note.
 - A number of students were absent from this session since they were attending the SEA awards function.
- Case 1- Two to the power of one, pp. 159-163.
Student questions, p. 186.
- S.I.1 - Sephra, Marian and Allison were interviewed. I asked Marian about the incident where she had asked about two to the power of zero and began to look at the idea of laws/rules. Sephra gave an example from language arts where there are laws that you just learn.
- Allison was also wondering about it. She related powers to volumes and areas, and had no frame of reference for something to the power of zero. When probed further she went on to say that she did not know who had invented it.
- Case1 – Two to the power of zero, p. 165.

Student questions, pp. 187-188.

Thursday September 08 2005

- C.O.2 - The teacher began by correcting the previous day's assignment. Students went to the chalkboard and worked.
- This was followed by a demonstration of how to write numbers in different bases and a note was dictated by the teacher to the class. During this period the students asked a number of questions such as: "Could there be base one?" and "Could a base number have two digits in it?"
- Student questions, p. 186.
-

- There was a review of writing base ten numbers in expanded form.

Time ran out, the teacher quickly gave a heading for the day's lesson

"Expanded notation for numbers in different bases" and assigned

homework.

Friday September 09 2005

S.I.2 - I met with Nadine, Jane, Naobi, Aaliyah, Lillian, Antonia and Allison. I

initially asked about their questionnaire responses.

- I asked Jane about what she meant by complicated problems. She indicated that these were problems where one solution did not work and one had to try other things. She concluded by saying that what she really did not like was getting frustrated.

Challenging and complicated, p. 98.

- I questioned Lillian about her response where she said she disliked rules and principles that one did not understand but one could do the practices. In her reply she suggested that mathematics has rules to go by, but that one could do exercises and get them out without understanding how or why.

Challenging and complicated, p. 99.

- I asked Nadine about her question from the previous day about bases with two digits. Her question had originated out of curiosity and she admitted that she was still confused. This question led to contributions from other students present. Aaliyah believed that it could not be done.

- I next asked about whether they were satisfied with their teacher's explanation. Jane responded affirmatively while Naobi said no. Naobi found that the explanation did not make complete sense. The others agreed that the explanation was satisfactory when combined with the textbook.

Student questions p. 188.

- Next I asked whether they found math class to be enjoyable so far. Aaliyah responded that it was but that all the material had been done already and was boring. Naobi used the words "monotonous" and "not challenging enough".

- There was agreement when I asked whether they liked their teacher. Jane said she gave good examples, Antonia liked the way she moved around the class and Lillian suggested that she spoke to them as friends.

Teacher actions that are internally persuasive, p. 190.

- I probed the two to the zero incident with these students. Jane found Marian's question was good.

- When Allison came in I asked about her response where she talked about clue words. She said she first heard them from her primary school teacher. Aaliyah said that she was also familiar and that clue words gave hints about what to do in solving problems. Jane added that these are things that you needed to focus on in the problem to solve it. Naobi referred to her questionnaire conception of mathematics and suggested that clue words indicated exactly what must be done.

Problem solving skills, pp. 115-116.

C.O.3 - After some preliminary interaction between teacher and students, the preceding day's homework was corrected. Using the input of students Saraswati reviewed the addition of numbers in base ten. This was followed by a teacher worked example on the chalkboard. Next she assigned the class to read the examples provided in the text. Students quickly completed this task and began to talk. Saraswati moved around helping a few students individually. Next she assigned questions which were to be started in class and completed at home over the weekend.

T.I.2 - Saraswati expressed relief that the first week was over and thought that the students were no longer scared, that they were excited and willing to learn though some were bored. In this latter case she made reference to those who were in the top 100.

- I asked about her previously expressed view that it was important for students to like her. She saw it as being important in maintaining students'

Mathematics teaching, p. 137.

interest and hoped they would pay more attention as a result.

- I asked why she had chosen to begin with the topic, number bases. She responded that it was the first thing on the scheme of work which the department had created based on the SEMP Syllabus. She explained that while she did not mind starting with the topic numbers she did not see the relevance of studying number bases at this time.

- Next we reviewed what I considered to be interesting incidents. I asked about Marian's "two to the power of zero". Her recollection was hazy and she was concerned whether or not she had given a "wrong answer".

Case 1 – 2 to the power of zero, p. 166.

- My next question focused on how she would like to teach. She said that she would like to use more visual aids and go to the audio-visual room but was constrained by the heavy demands placed on the single facility by other teachers. She also said that the classroom was too large, that there were too many students and these constrained how she felt she could teach.

- Finally I asked about Nadine's question about base twelve. She was wondering why the students were asking her so many questions since her previous classes had never asked so many, and she wondered if it was because they were being taped or if they really were outspoken.

End of 1st Week

Table 5.2

Overview of second week

Event	Significant events/utterances	Discussed
<i>Monday 12 September 2005</i>		
C.O.4	- Homework was corrected. Saraswati elaborated, modeling via her speech the type of reasoning and answer that she expected. When Priscilla	Homework, p. 151.

answered wrongly there was an immediate low murmur. Saraswati quickly asked another student who provided the correct answer. Saraswati then prompted her to provide an explanation.

- Saraswati stated the title of the day's lesson, "*Converting base ten numbers to numbers in other bases.*" She then read a note for the students as a series of five steps or algorithm to be followed. This was followed by a worked example on the board which the students copied.

- Upon completing this Katija remarked that she did not understand the relation between the two numbers. Bell rang and homework was assigned.

Case 2- What's the relation?, pp. 167-171.
Student questions, p. 186.

S.I.3 - I interviewed Katija, Marian, Parvati, Cynthia, Xumei and Yeng.

- I began by asking Katija and the group about her question regarding the relation between the two numbers. Marian was confused as to why the remainders were written backwards (in reverse order) and Katija about why one used remainders at all.

Case 2 – What's the relation?, p. 173.

- A response on Cynthia's questionnaire described a good maths teacher as being dedicated. I used this as a probe to get students to elaborate on what made a good mathematics teacher.

Mathematics teacher-patience, pp. 124-125.

- I returned to questions I posed on Friday. I asked about "clue words" and whether all math questions have only one right answer. There were answers in both the affirmative and the negative. Next I asked what they thought teachers looked for in answers. Jasmine suggested proper working.

- When I asked whether math class was fun so far, they all nodded in agreement. A discussion of what fun meant for students ensued which emphasized the teacher's role, the classroom climate and being "loose". I also asked whether it could ever stop being fun. Students made reference to being pressured, not understanding and lacking a voice.

Teacher's actions that are internally persuasive, p. 190.

	<p>- I returned to the question of “two to the power of zero”. Marian was still confused. We looked at that portion of the class where Saraswati said 2 to the power of zero was one. Katija was not happy with the explanation. Some discussion and confusion ensued. No conclusion was reached or attempted.</p>	<p>Student questions, p. 188.</p>
	<p>- Finally I asked about differences between primary and secondary experience. Marian was confused about the division procedure from earlier in the day. She was not sure why the division proceeded downwards though Xumei seemed to have seen this type of division before.</p>	
T.I.3	<p>- We reviewed classroom clips and commented on them. I inquired as to how she selected students to answer questions. She indicated that it was to give everyone a chance and to make sure that everyone did the assignment.</p> <p>- We looked at the incident from earlier in the day when two students got their answers wrong and she moved on to another student. She explained her reasons for doing this.</p>	
	<p>- We looked next at Katija’s question of the relation between the two numbers. She was unsure what Katija meant by relationship. I decided to show the relevant portions of the earlier student interview which had not yet been transcribed as I felt it would help to uncover what Katija meant and might assist Saraswati in addressing the question. She was concerned that Katija did not understand why there were two different numbers. She began to think to herself how she could answer the question, and began to internalize and wondered what she was doing in teaching.</p>	<p>Authoritative discourse and Saraswati, p. 177.</p> <p>Hearing students’ responses, pp. 201-202.</p>
	<p>- I illustrated what I thought Katija’s problem was. She admitted that she had never looked at it in depth and suggested a reproductive view - of history repeating itself.</p>	<p>Structuring authoritative discourse, p. 149.</p>
	<p>- I informed her that several students appeared to be having problems with</p>	<p>Case 1- 2 to the power of zero, p.</p>

two to the zero. We looked at the students discussing their problem with two to the power of zero and with the division notation.

166.

Tuesday 13 September 2005

- C.O.5 - Aaliyah did the single homework question on the chalkboard during which time Saraswati moved around and examined books.
- Aaliyah then showed Saraswati a method she had “worked out” to check her answer. Saraswati invited her to share it with the class. The teacher asked the class to applaud Aaliyah at the end.
 - Next Saraswati assigned problems to be completed in class. As students worked Saraswati moved around checking on them. From my vantage point I could observe students making two errors – omitting zero remainders and writing the remainders in the wrong order. Some time later Saraswati announced not to omit the zeroes and referred back to the base ten system.
 - Students went to the board to write their answers and working down and returned to their seats. Allison made a few mistakes including writing the remainders in the wrong order. Naobi made a comment which caused the class to laugh. The bell went and homework was assigned.

Case 2 – student errors, pp. 174-175.

Wednesday 14 September 2005

- C.O.6 - The class began with students correcting and explaining homework.
- Saraswati announced the topic, “*Converting numbers in other bases back to base ten*” and called on Aaliyah to repeat the method she had demonstrated previously. Both Aaliyah and the teacher explained the method for the class.
 - Next Saraswati assigned a single example for the class to practice with. The bell went and Saraswati kept the class in for a few minutes to correct the problem and assigned problems for homework.

Homework, p. 152.

- S.I.4a - I met briefly with Naobi, Aaliyah and Jane. I asked about the applause that they had received the previous day. Aaliyah said it was nothing really special since they were accustomed to it. Naobi said she felt good that the class appreciated it but she was also accustomed to it. Aaliyah hinted that she did not really want to share, because it might have helped her to place first at the end of term.
- I asked about everyone getting a chance. Naobi said she understood why and thought it was fair so that people would not be left out but found it annoying because she wanted to move on.
- I asked about why the methods they were using worked and which they saw as more important- to know why it works or how to do it. Aaliyah offered that if you knew why then you would know how, Naobi suggested both are important, Jane agreed that both are important but stressed that you should know how to do it.
- Giving everybody a chance, p. 192.
- T.I.4 - I asked about the previous day's class which I interpreted as being mostly a practice class. Saraswati explained that she wanted to see if they understood and what kind of errors they were making. She recounted that she discovered a common mistake – not putting zero and felt that it was her fault for not explaining properly suggesting it was because she had not given them an example with zero remainders.
- I asked about how closely she kept to the lesson plan she brought to class. She said that she stuck to it but found that she did not usually finish what was on the plan because she focused on correcting homework. I asked about this and she reasoned that homework was important and by going through it she could see how well they understood it and could “pull out” any problem areas.
- I wondered about what influence my presence might be having in the
- Authoritative discourse and Saraswati, p. 177.

class. She described not being as nervous as the first few days but was upset by the comments she had heard on the tapes.

Hearing students' responses, p. 203.

- Saraswati was also concerned that students were assessing her, which she suggested was worse than another person like myself assessing her. She expressed feelings of hurt at being assessed by students and their telling me.

- S.I. 4b - I met with Bridgette, Ang, Allison and Marian at lunch time. I asked what they thought about the teacher giving everyone a chance to work problems. They suggested several advantages including it being fair and helping to uncover mistakes quickly.
- I attempted to get at why they thought students were making the mistake of writing remainders in the "wrong" direction. Ang included the other common mistake that was spoken about, omitting zeroes. She went on to explain that it was not usual to put remainder zeroes.
- I asked whether it was more important to know how the method works or why it works. Allison wanted to know why it works. Ang wanted to know how to do it and offered that if you know why you might not know how, but if you knew how then you knew how to answer the sum. Allison agreed, she could do it but still wanted to know the reasoning behind using the remainders, writing them backwards and putting the number to the given base.
- I asked again about two to the power of zero. Ang used Saraswati's explanation.

Thursday 15 September 2005

- C.O.7 - Class began with the correcting of homework. Saraswati again walked around examining students' books while other students presented their working on the chalkboard.
-

- Saraswati invited Naobi to demonstrate the method for converting numbers in other bases back to base ten using repeated multiplication. Naobi made a few mistakes and Allison responded sarcastically which caused Naobi to become defensive and aggressive. Saraswati quickly regained control of the class and allowed Naobi to continue. When Naobi is asked to explain she goes through the algorithm, Ophelia asked her if she could check that her answers were correct, she tried to do so but forgot and became impatient. As the class became noisier Saraswati took back control in a friendly manner. Saraswati then demonstrated the method of repeated division.

- Ophelia was concerned with the amount of space this method uses.
- Allison asked about the last digit. Saraswati explained that once you used the last digit you did not multiply again.
- Towards the end of class Saraswati informed them that there would be an assessment in the near future.

Student questions,
p. 186.
Case 3- The last
digit, pp. 179-181.

Friday 16 September 2005

- S.I.5a - I met with Naobi, Aaliyah, Allison, and Ophelia at recess. I began by asking Naobi if she was being challenged as yet, she responded negatively. Allison found the topic easy but tricky while Aaliyah also stated that she found it lacked challenge.
- I questioned Ophelia about her concern for the amount of space taken up by the problem. She felt that it was a waste of paper for one sum. They referred to the SEA exams where they were given a specified space to work problems.
- My next question asked whether they thought too much time was being spent correcting homework. Aaliyah responded negatively viewing it as practice, Naobi found it monotonous while Ophelia viewed it as a review.
- Naobi outlined a sequence of events for classes stating that the class is

Homework, p. 153.

teaching followed by homework and that she desired something different and more challenging.

- I asked about teachers who gave notes. Aaliyah was adamant that a teacher must not only give notes but must explain the questions as well. Naobi did not want to take a note of something she already knew describing it as tedious.

- I inquired about what they thought other students felt about them getting so much attention in class. Naobi described feeling that she was attacked verbally. Aaliyah felt good getting attention. Allison said she felt jealous.

Other students' utterances that are internally persuasive, pp. 196-197.

- I asked about why the last digit wasn't multiplied. Naobi who had demonstrated thought it was because that's where the number ended. Ophelia also did not understand. Aaliyah reasoned that you continued multiplying only if there was another digit.

S.I.5b - Lillian, Jasmine and Michelle met with me at lunch time. I asked Lillian about her questionnaire response about rules. She drew reference both to Saraswati's and Naobi's explanation as being deficient but that she was still able to do the problems. She did not understand how it was done though she was able to do her homework. She also did not understand aspects of the repeated multiplication method. Michelle added that she too did not know why and expressed that it was a rule to be followed.

Doing without understanding, p. 182.

- I asked about why we stopped at the last digit. Lillian expressed some confusion about this. Michelle suggested that it was because the teacher said to and that there were no other digits. Katija argued that since all the numbers had been used up one must stop.

- I also probed whether they thought too much time was spent correcting homework.

Homework, p. 154

- I asked whether they felt that some people were getting too much

Other students' utterances that are

attention. They laughed and Lillian said that she felt left out. Michelle was more critical and also felt angry and left out.

internally persuasive, pp. 194-195.

- Lillian explained that she did not speak up in class but waited for the teacher to come around to ask things that she did not understand. She added that she did not like people staring at her.

- C.O.8 - Saraswati began by describing what the test was going to be like. Next she called a note on the *Conversion of numbers in a given base back to base ten using the method of repeated multiplication*. This was given as a series of steps. This was followed by an example to be worked by the students during which time the teacher moved around.
- There was some discussion again of why no further multiplication was needed when the last digit is reached.

- T.I.5 - Saraswati expressed that students were becoming more open, asking more questions and seemed more comfortable than the previous week.
- I asked about the incidents where Aaliyah and Naobi taught. She was pleased with Aaliyah but felt that Naobi did not relay what she knew well and had expected more.
- I questioned her about the reason for not multiplying the last digit to which she responded that it was the last digit and “it just ends”.
- I probed her use of textbooks to which she replied that she does all the assignments and used it to guide the sequence of topics that she teaches. She also related that the school felt compelled to use the book.
- Saraswati received a phone call and had to curtail the interview.

Hearing students’ responses, pp. 200-201.

The whole thing just ends, p. 183.

End of 2nd Week

Table 5.3

Overview of Final Week

Event	Significant events/ utterances	Discussed
<i>Monday September 19 2005</i>		
CO9	<p>- Students worked at the chalkboard correcting homework while Saraswati moved around checking individual students. Following this Saraswati gave instructions and answered questions relating to the upcoming exam/assessment activity.</p>	
S.I.6	<p>- Jasmine, Rose and Bridgette were interviewed on this day. I asked about why the repeated multiplication method ended where it did to which Rose responded that that there was nothing else to multiply.</p> <p>- I asked them about whether it was more important to know how or why a method worked. Referring to Aaliyah's method, Rose stated that it worked because it was logical, because there were steps to follow and a certain way to do it.</p> <p>- I asked whether they thought some people were getting too much attention. Rose found that some persons tended to question authority.</p> <p>- They were finding classes enjoyable. Rose attributed this to the teacher who made her feel comfortable. Bridgette said it could stop being fun or enjoyable when it got more difficult while Jasmine suggested that a bad teacher who gave homework and did not explain would have the same effect.</p>	<p>Teacher's actions that are internally persuasive, p. 190.</p>
<i>Tuesday September 20 2005</i>		
C.O.10	<p>Saraswati was absent. Students spent the period conversing with their friends or reading.</p>	
<i>Wednesday September 21 2005</i>		

C.O.11 - The school had a pre-arranged activity and classes were suspended.

Thursday September 22 2005

C.O.12 - Saraswati set the tone of the exam as serious. She gave instructions for the test. During the test students asked questions to which Saraswati often shrugged and smiled but did not reply verbally. After the test Naobi was distraught and emotional. Nadine attempted to console her.

Friday September 23 2005

C.O.13 - There was a bomb scare and the school was evacuated. Classes resumed after the math period. This was the last agreed upon day which I could observe students in class.

Monday September 26 2005

S.I.7 - I met with Aaliyah, Naobi, Allison and Jane in this brief and final onsite interview.

- They found the test easy. Aaliyah was uncertain of what was being asked in some questions. Naobi thought that it was necessary to specify which method should be used.

- Naobi explained that that the review that they had done earlier in class helped them to see where (and how) they had lost marks. She also commented that this was the first time she was uncertain about her mathematical performance.

Testing/Evaluation,
p. 156.
Other students'
utterances that are
internally
persuasive, p. 200.

- Aaliyah also explained that she was not accustomed to writing in pen. Naobi also attributed her performance partly to the use of pens.

Testing/Evaluation,
p. 157.

T.I.6 - This interview was divided into three segments.

- In the first segment I asked about aspects of the test. When marking Saraswati said she was looking for the answer in the first two questions and that she wanted to see what they had understood by expand. She also noted that some persons had confused the different methods. Everyone

Testing/Evaluation,
p. 156.

passed the assessment, the lowest was 19 (out of 38) and twenty seven out of 39 students made 30 or over.

- In reviewing the test in class she invited them to the board and showed them where they lost marks.

Testing/Evaluation, p. 155.
- Several students stood out for her based on the exam. She noticed that quiet students did well and was especially surprised by Allison whom she felt was disorganized.

Changing conceptions of students, pp. 198-199.
- Next we looked at the conceptions questionnaire which she had been unable to complete in written form so we went through the questions orally. The responses to this questionnaire are incorporated into Chapter 6

Saraswati's mathematical discourse models, pp. 127-142.
- Finally we discussed why the different methods worked. Saraswati expressed a belief that mathematicians many years ago had proved it and that this was the best explanation for students.

Structuring authoritative discourse, p. 149.
- She was glad the taping was finally over and did not think that it had disrupted the class abnormally.

End of On-site Observations

Summary

In this chapter I have attempted to provide a broad overview of the research program as it unfolded onsite so that incidents discussed in the analytic section might be situated in their appropriate context of utterances and replies. In addition, this provides a sense of the rhythm of the research as well of the classroom. In the next chapter I will examine the conceptions that students and their teacher brought to the classroom at the beginning of the year.

CHAPTER 6

PRIOR DISCOURSE MODELS

Discourse models are simplified, often unconscious and taken-for granted, theories about how the world works... We learn them from experiences we have had, but crucially, as these experiences are shaped and normed by the social and cultural groups to which we belong. From such experiences we infer what is “normal” or “typical.” (Gee, 2004, p. 71)

Discourse models can be about “appropriate” attitudes, viewpoints, beliefs and values; “appropriate” ways of acting, interacting, participating, and participant structures; “appropriate” ways of talking, listening, writing, reading, and communicating; “appropriate” ways to feel or display emotion... (Gee, 2004, p. 83)

Students and teachers in Trinidad and Tobago and elsewhere who meet each other for the first time in a Form One classroom come already as participants immersed in a number of socio-historical Discourses. These include Discourses relating to education, teaching and learning. A particular feature of these prior or historical discourses is their referencing of the words and actions of historical others who are no longer (physically) present. I have not tried here to separate authoritative from internally persuasive discourses since the struggle between both of these types would have contributed to these individuals’ “ideological becomings” and both would have influenced the conceptions that they now hold.

In this chapter I examine the question “what conceptions of mathematics do students and their teacher bring into their nascent classroom community at the beginning of the school year” or, stated another way, what type(s) of discourse models do they espouse regarding mathematics as a domain, their own relation to mathematics and mathematics teaching and learning? I will not attempt to engage in how these interact as I leave that discussion for a later chapter. However it is important to appreciate the

diversity and similarity of students' conceptions as well as the congruencies and incongruencies between students and teacher's conceptions. I draw on data provided mainly by the questionnaire (Appendix B), classroom observations as well as interviews.

Students' Prior Discourses

The Domain of Mathematics

In this first section I examine students' discourse models of mathematics as a domain of study/discipline. The responses to four questions from the questionnaire constitute the initial data. These questions were '*What is mathematics about?*' '*What do you like about mathematics?*' '*What do you dislike about mathematics?*' and '*Do you think mathematics is useful outside of school?*'

Numbers, Calculating and Solving Problems

The majority of students' responses to the question of '*What is mathematics about?*' revolved around three interrelated themes/conceptions of mathematics. These themes are mathematics is about calculating or numbers, mathematics is about solving problems and mathematics is about applying basic rules. These three conceptions have been previously identified in the literature (e.g McLeod, 1992; Schoenfeld, 1992) among students of this age.

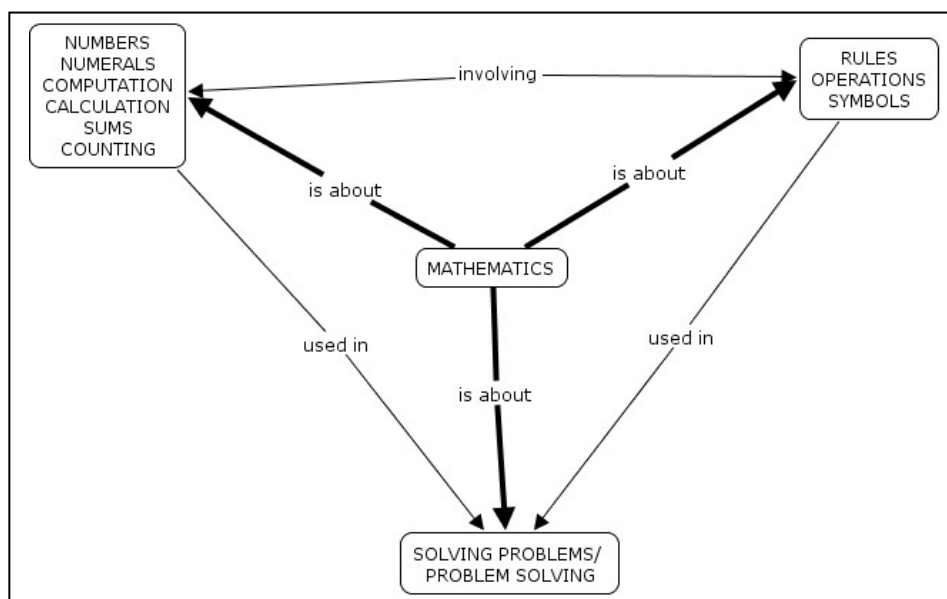
The majority of responses (18) refer to counting, computation, calculation or working with numbers or numerals, to describe what they view as constituting mathematical activity. This conception is stated succinctly by Xumei who writes, "I think mathematics is about computation." This numerical bias towards mathematics is supported by students' other conception regarding the four basic arithmetical rules. Parvati, for example states that "mathematics is about numerals and applying them in many different ways to the four rules, add, subtract, divide, multiply." The same idea is

expressed by Cynthia: “mathematics is about the relationship with numbers and symbols.” Here she equates the four arithmetical operations with their representative (and equivalent) symbols. These two conceptions reinforce each other through the third that mathematics is about solving problems. All three themes for example are present in Yeng’s statement that “mathematics is about calculating or solving mathematical problems and enjoying yourself with numbers” and to a similar extent in Jane’s “Mathematics is about the four laws: adding, subtracting, multiplying and dividing and also about word problems that can be tricky.” From the student responses one is led to suspect that ‘solving problems’ involving numerical computation utilizing the four basic arithmetic operations seems to have been the focus of much of these students primary school experience of mathematics.

Among the (13) respondents initially coded as writing about problem solving the construction ‘solving problems’ was used by all but one who used the alternative construction, problem solving. In the former the focus is on the process of ‘solving’ while in the latter the object of focus is the problem. This is interesting because of the way these two terms are generally utilized by mathematicians. Mathematical Discourses generally use “problem solving” to refer to an ill-defined process of problem formulation, exploration, discovery and formal proof (solution). “Solving problems,” on the other hand, suggests a more routinized and mechanical activity in which problems are given whose solutions are already known and the ‘thing’ that one has to do is ‘solve it’ correctly.

Students’ conceptions of what mathematics is about is summarized in Figure 6.1 below.

Figure 6.1: Concept map of students' conception of what mathematics is about.



Utility

The strong confluence among responses from students who have come from a number of different primary schools, suggests that this discourse model (Figure 6.1) is pervasive. It is a very limited view of the discipline of mathematics. It also fosters a narrow view of mathematics' utility.

Students' views of mathematics' utility outside of school centered on mathematical activities in "everyday life." Their examples of purchasing, making change, paying bills, budgeting and calculating taxes, are generally referred to as consumer arithmetic. Allison captures most of these in her statement that mathematics, "can be very useful like when you want to tell the time, measuring your height, calculating both money and bills, budgeting, value added tax and many more." The use of mathematics for measurement is also part of Allison's statement and this emerged as a very minor but related theme. The second major view held by students was that mathematics was important in obtaining a job. These jobs included that of cashier, engineer, accountant,

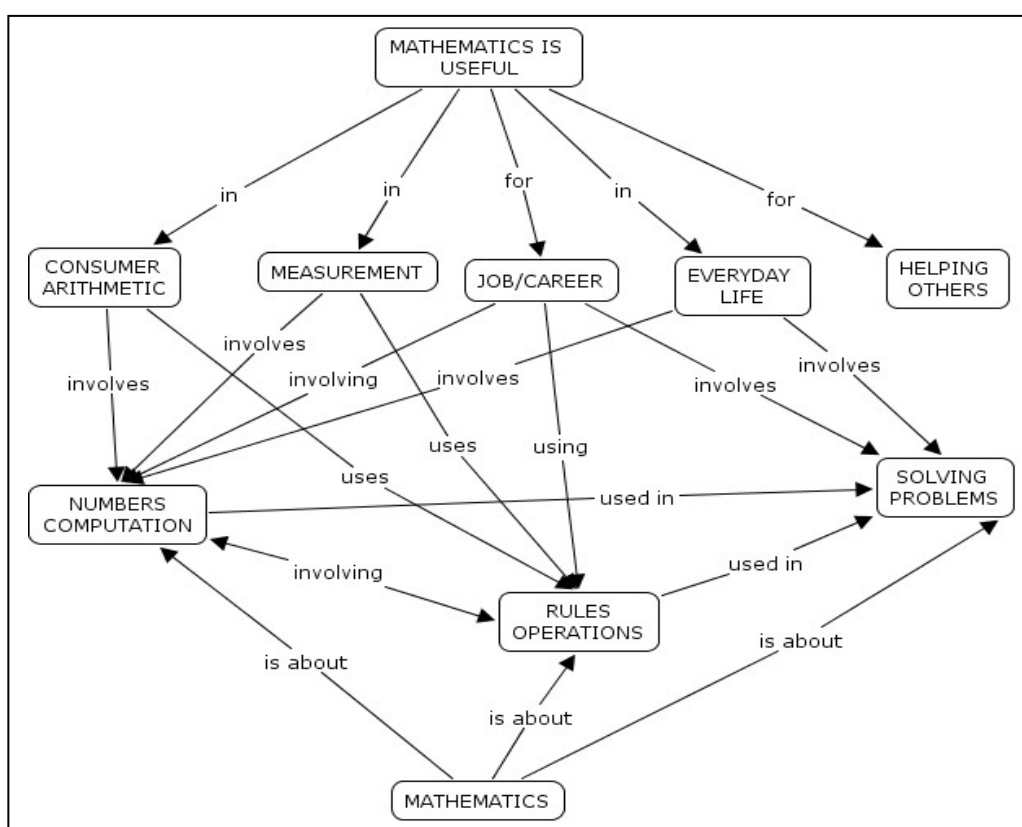
business owner, physicist, and chef. Some students were not as specific and simply explained that “every job in the world requires mathematics.” In a similar vein several students simply referred to mathematics being useful in everyday life without providing any further elaboration. These findings are similar to those of Kloosterman, Raymond and Emenaker (1996) in their longitudinal study.

These conceptions regarding mathematics’ utility outside of school are related to the views of mathematics as being about numbers, computation, arithmetic operations and problem solving discussed above. When Victoria, for example, writes that, “mathematics is useful outside of school because everything requires adding or taking away or even multiplying and dividing” she appears to be expressing a view that directly links mathematics’ utility with the *operations* that she posits as comprising mathematical activity. The jobs that the students identify all involve working with numbers and computation. The nebulous concept of everyday life which is used by a number of students seems to suggest there is a ‘privileged pervasiveness’ to mathematics utility that cannot be fully articulated. A portion of this utility in everyday life might be linked to the view expressed above of mathematics as solving problems/problem solving as Naobi suggests when she writes, “many everyday life situations requires the *skills* which mathematics affords” while it may also refer to those actions mentioned previously involving consumer decisions and measurement.

Finally, there are two statements that are incongruent with the others and which open a small window on a possible social utilitarian conception of mathematics. Both suggest that learning mathematics might be employed to help others, in one case these others are “siblings” and in the other “people who don’t know how to count and stuff.”

Like the conceptions regarding what is mathematics about, the conceptions of mathematics' utility show little diversity across students. Mathematics has a concrete utility in terms of consumer arithmetic, measurement and some jobs, it also has a more nebulous utility as a part of everyday life. These are closely linked to the views of mathematics as being largely computational. Finally students also appear to express a small social dimension to mathematics' utility.

Figure 6.2: Concept map of students' conceptions of mathematics utility



The first two questions (what is mathematics about and its usefulness outside of school) required little personal investment from students and revealed a limited set of (largely) interrelated conceptions of mathematics and its utility. The next two questions asked specifically about what students liked and disliked about mathematics and in both cases a diverse set of factors were elicited reflecting the highly subjective nature of

individual mathematical experience. However, several themes did emerge. Students reported liking challenge, solving problems, using different methods, that mathematics was interesting, its certainty, its utility in everyday life, feelings of satisfaction and pride, their teacher and that mathematics was fun. While several students reported that there was nothing that they did not dislike about mathematics others reported that feelings of frustration and stress, complicated problems, taking notes, poor explanations, lack of understanding of rules and specific topics were all things that they disliked about mathematics. In both cases, likes and dislikes, the contributing factors relate to mathematics as a domain, individual affective responses and mathematics teaching. These are inter-related with one another and with the prior discourse models described above.

Challenging and Complicated

Many of the student responses (12) use the word “challenge” to describe what they like about mathematics. What is interesting is that the word challenge is employed as both a verb and a noun by different students. Gertrude for example typifies those who use challenge as a verb, “I enjoy mathematics because it challenges and exercises your brain.” Mathematics is here placed in a subject role where it does something *to* the individual – challenges, which is enjoyable. This construction stresses the enjoyable *activity* of mathematics. Jane on the other hand uses challenge as a noun, “I like the challenge in mathematics and I also find math fun” as does Ophelia “I love the challenge you get when doing mathematics and the relief after working out a particularly hard sum.” Here the students place themselves in the subject position (as opposed to mathematics). However mathematics is not placed in the object position; rather, through engagement with mathematics, the inherent challenge becomes realized. In this case

challenge is being viewed as an enjoyable *thing* or state of being/feeling. These multiple senses in which challenge is used here and the frequency with which it is used suggest that it is an integral part of these students' discourse model regarding mathematics.

Challenge suggests that mathematics is being viewed as an opponent or something to be overcome. This idea finds resonance with Walkerdine (1988) who argues that this particular student discourse is "...a fantasy of omnipotent power and control of the universe" (p. 199). It also seems to be closely linked with the idea of testing, of being challenged, which is congruent with these students' prior experiences with the SEA examination in which they have done exceptionally well and in which mathematics was a major part. They have met the challenge and have overcome. This elicits a number of affective responses which describe the feelings associated with succeeding in meeting/overcoming a challenge. Ophelia uses the word "relief" to describe her catharsis upon successfully working out a "difficult question", while Parvati writes of her experience of self-worth, "...you feel a sense of satisfaction and pride" that is a direct result of "solving a difficult problem." Others such as Jane simply find math "fun." In this discourse then as Walkerdine (1988) notes "...is the pleasure of beating and the pain of being beaten..." (p. 201).

This link between overcoming mathematical challenges and experiencing positive affect also helps to explain students' dislike of 'complicated' problems and their associated feelings of "frustration" "stress", anxiety, and "disappointment". A typical example of this is provided by Nadine, who states that, "the only thing I dislike about mathematics is that sometimes it gets very difficult to understand and it gets me really frustrated." Parvati, who expressed strong feelings of self-worth above also expresses strong negative feelings: "I dislike mathematics because when you work so hard on the

sum and you put so much effort into it and then you get it wrong it makes you feel disappointed.” For Allison it is speed tests that “builds up [her] anxiety.” These statements reveal another dimension of challenge – that challenges that are not easily met, that are in fact very challenging, create a sense of personal anguish for students. Students’ conception of mathematics as challenge is thus intimately linked to their own identities through the affective reactions that they have as they engage in mathematical challenge. This supports the calls in the literature for self-regulatory skills to be seen as an important part of developing a productive mathematical disposition (e.g. DeCorte et al. 2000).

The word “complicated” stands in sharp contrast to that of “challenge”. In examining the student questionnaire responses complicated was used to describe problems that were “really long” or “difficult to understand” as well as for specific topics within mathematics, such as “equations,” percentages and lengthy calculations. Research on word problems does support the view that a lengthy statement is generally thought to be more difficult than the equivalent numerical problem (e.g. Reed, 1999). Students’ difficulty understanding seems to have two components – a view of mathematical activity that posits that one correct/proper way to work/solve a mathematical problem and a feeling of dissonance as a result of being able to solve mathematical problems without understanding the underlying mathematical principles, i.e. a view of mathematics as mystery. These two positions are illustrated by statements from Jane and Lillian respectively during one interview (S.I.2).

I: Jane, so on your questionnaire you said that you dislike complicated problems. What do you mean by a complicated problem? What’s a complicated problem for you? 1

Jane: Problems with..., like if you try one solution it doesn’t work so you have to keep going at

	it.	2
I:	Okay, and why do you dislike complicated problems?	3
Jane:	[matter of factly] Because...they're complicated and it's be hard to solve them and I get frustrated.	4
Jane:	I ...prefer challenging problems ...but when I start getting frustrated then [softly] it becomes a problem.	9
I:	Lillian...you said on your questionnaire that you 'disliked the rules and principles and its difficult to understand by doing the practices and not know exactly you did it.' What did you mean by that? I didn't quite understand...	35
Lillian:	Cause in maths it have a set of rules you have to go by and when you do practices you just do it and you don't know how you get that and the teacher try to explain but you still don't understand cause the rules complicated to understand.	36

In Jane's excerpt the link between complication and frustration is again made clear, however we also see that when a problem does not yield immediately to the first approach tried that it is no longer challenging but complicated and results in frustration. Lillian adds a different (but related) perspective. It is the lack of understanding of how the rules that she is told to use work that renders these rules and principles complicated and it is this that she dislikes. In the next chapter I will engage more fully with this conception of a lack of understanding of rules and "just doing it."

Complicated and challenging are both used to refer to the main feature of what students liked about mathematics – solving problems. For some students solving problems is tied in to a numerical view of mathematics and an everyday utilitarianism. However for others what they like about solving problems and mathematics is the diversity of rules and methods. For example Sephra writes, "I like when you are able to figure out problems from using different methods." There is a fine line between liking the ability to use different methods and the inability to find *the* method that works.

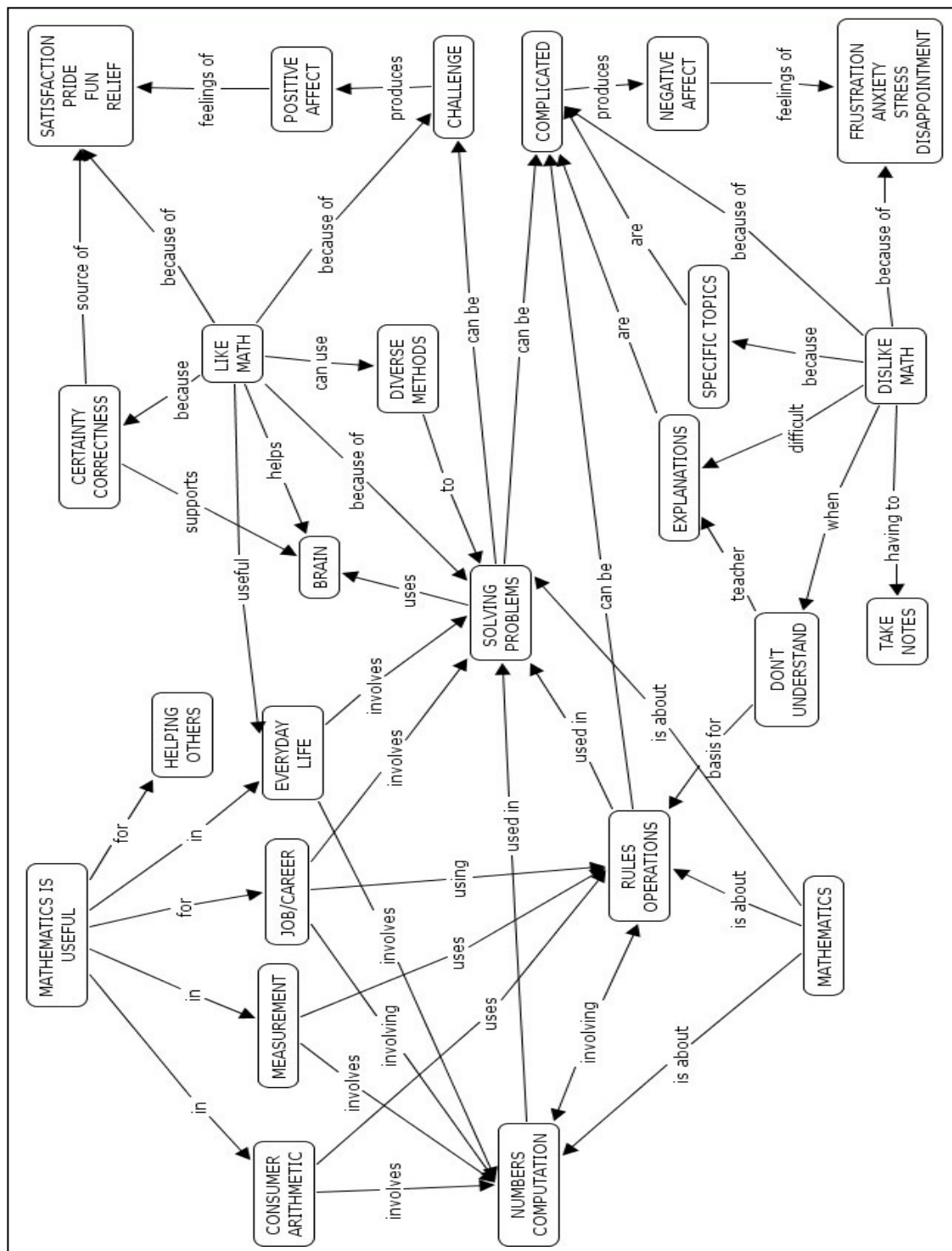
Students also expressed a predilection for mathematics because of the ability to verify that one's answer and methods are correct. This certainty regarding one's answer and method is comforting and is the source of the feelings of positive affect described earlier. Aaliyah expresses such a sentiment when she writes, "I like maths because unlike other subjects you can actually check your working to see if you have the correct answer." Here mathematics is placed in a superior position to other subjects because of this view of an ability to be certain regarding what is seen to be substance of mathematics, solving problems using rules (methods), and its claim to correctness.

Linked to this conception of correctness is a general view which regards mathematics as a mental discipline. Students use the phrases "exercises your brain," "mentally...you become more alert," "involves a lot of brain power," "it makes your brain think" and "brainstorming the questions" to describe not only where they perceive mathematical activities to be localized but also to describe the effect that such activity has on the brain. In addition, some students also express a view of speed of working that is linked to the views of correctness and being brain based. Michelle, for example, writes that she likes, "Problem solving because it makes your brain think and mental because you have to know the answer at the tip of your head which means you have to think fast and correctly." These ideas are related to conceptions of mathematics learning as well as conceptions regarding mathematical ability and will be discussed in later sections.

Some of the other aspects of this discourse model regarding mathematics as a domain, such as note taking, poor explanations, and the influence of the teacher are tied in with conceptions of mathematics teaching and will be discussed in that section.

In this section students' espoused and evaluative discourse models of mathematics as a domain have been explored. These are illustrated in the concept map below (Figure 6.3).

Figure 6.3: Concept map of students' conceptions of mathematics as a domain.



The Self in Relation to Mathematics

In the previous section themes relating to students' conceptions of mathematics as a domain were explored. In this section I look more closely at how students described their own relationship to mathematics. The responses to three questions from the questionnaire constitute the initial data. These questions were, '*Is mathematics an important subject to you? Why or Why not?*', '*Do you consider yourself good in mathematics?*' and '*Do you find mathematics easy to understand?*'

Importance = Utility

The responses to the question "Is mathematics an important subject to you?" were very similar to the responses elicited by the question "Do you think mathematics is useful outside of school?" In both cases mathematics is valued by the majority of the students because of its perceived pervasiveness in everyday life as well as being an essential requirement for obtaining a job. However there are fewer descriptions here of the type of jobs or of how mathematics is used in everyday life. Those that do, again make reference to calculation and consumer arithmetic. There seems to exist then a close alignment between students' espoused beliefs regarding mathematics' utility in general and their perceived value of mathematics.

Underlying the 'job' theme is a particular discourse model regarding the links between mathematics, education and future success. Consider the following questionnaire responses:

Lillian : It is because mathematics is one of the most important subjects I must pass in order to be able to achieve my life's goal...

Sephra: Mathematics is an important subject to me because to get through to good jobs like being a doctor, lawyer or the other, sometimes you must have a one [this refers to the highest grade] in math when it comes to A level or O level examinations.

Antonia : Mathematics is a very important subject to me because I need to be good in it to have a well-paying job.

From these and many similar excerpts, students seem to be expressing a strong future-goal orientation towards success in which they posit education in general and mathematical education in particular as playing a key role. The metaphor evokes the image of mathematics as a key that unlocks doors to future career opportunities, success and fulfillment. Mathematics facilitates “getting through” to the “good” and “well-paying” jobs and allows one to realize “one’s goals.” This is a widespread Discourse associated with educational systems in general.

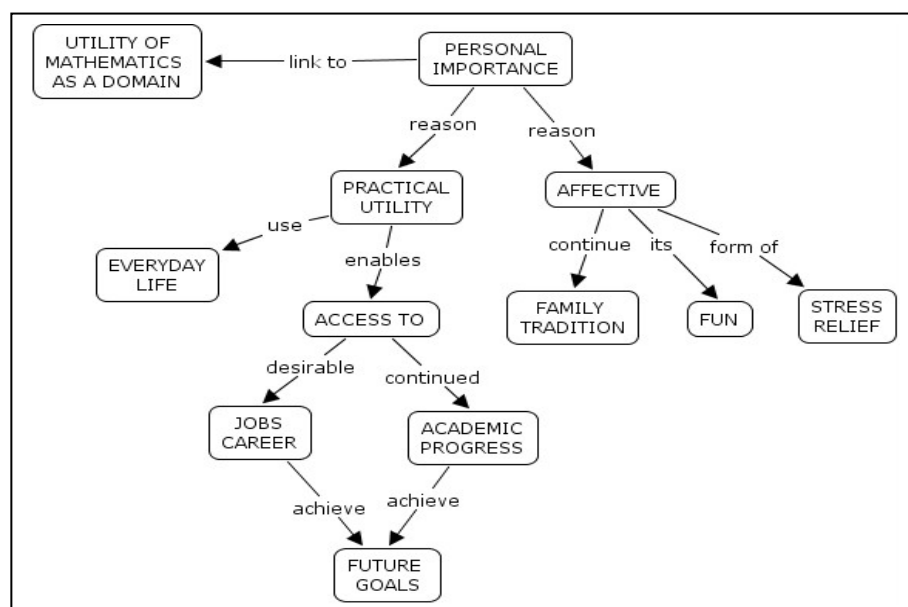
This strong goal orientation towards future success seems to be associated with a discourse model in which competition plays an important part. These students have been immersed in and have emerged successfully from a competitive examination situation in which mathematics played a significant role. Mathematics has been important in achieving their goals thus far, of gaining admission to their first-choice of secondary school. It is not unreasonable to assume that their view of mathematics as continuing to be important to achieving their goals and obtaining good jobs is influenced by the role already played by mathematics in their prior success. Further evidence for this is provided below.

The value of mathematics to individual students also includes finding it “fun”, a way to “relieve stress,” and wanting to continue a “family tradition” of excellence in

mathematics. These are more affectively oriented and are closely aligned to the personal significance of mathematics for these students.

Mathematics importance for students is due largely to its utilitarian value in everyday life and in securing a successful job. However students also posit personal and deeply affective values for mathematics. Possibly because of their prior success which depended on success in mathematics students are able to posit a future in which mathematics plays an integral part in realizing their educational aspirations.

Figure 6.4: Concept Map of students' conceptions of mathematics personal importance.



Ability

Students' views of their mathematical ability are overwhelmingly positive. A few students whose responses are ambivalent or noncommittal might be categorized as having a realistic but optimistic view of their ability. For example Priscilla describes her ability as average since she is constantly improving while Cerise describes her ability as “basically good at mathematics but at some point I have difficulties...” There is a

reticence among this minority of students to claim for themselves a self-concept of above average ability.

The majority of students in this class however, claim a positive self-concept regarding their mathematical ability. Students' own justifications for their statement include references to positive reinforcement from both external and internal sources. In the former case, students base their judgment of their mathematical ability on their performance in external assessments and examinations in which they have performed well in the past. The following excerpts are typical of this:

Jane: I think I do well in mathematics since in all my years at my primary school I was among the top students in that subject area.

Diana: Yes I consider myself good in mathematics because for the past few years my scores have been 95 and up always. For example in the SEA examination I scored 97% in mathematics.

Victoria: I can say that I'm good in maths because I made 99 in the SEA exam maths Section... Ever since I've known myself I've always gotten 95 and over in every one of my maths test.

Naobi: I do. I think I am good at mathematics because I've never achieved less than 98% in maths.

These and other similar responses point to the importance of external assessment as a source of justification and knowledge about one's ability. However, they also reveal some very important dimensions of the Primary School Discourse. Being 'good' at mathematics seems to be restricted to students who are able to score in the highest percentiles. This may help to partially explain the reticent minority's unwillingness to commit to being seen as "good." Since they see themselves as "constantly improving" or "having difficulties" they are thus not consistently in the uppermost echelon of students.

One wonders though how students' views of their mathematical ability will change if their marks descend as they ascend through the higher forms? Given that for many their self-concept regarding mathematical ability is directly linked to their performance on assessment events it is likely that students' self concept will change or their view of mathematics will change. This discourse model that positions students' self concept regarding mathematical ability as dependent on external assessment is a powerful prior discourse.

Many students also base their mathematical self concept on internal sources of positive reinforcement. Several attributed their success to being able to understand mathematics quickly or when well explained as the following examples illustrate:

Nadine: I consider myself good in mathematics because I work problems faster than [other] students and I understand problems that others would not on their 1st or 2nd attempt.

Rena: ...I have no problem understanding things when explained properly ...

Jasmine: ...because I don't find it difficult to understand...

For these students understanding "properly", understanding "quickly" and ease of understanding are all hallmarks of being good in mathematics. These positive evaluations come not from external reinforcers such as assessments, but from an awareness of one's own cognition, from internal dialogues.

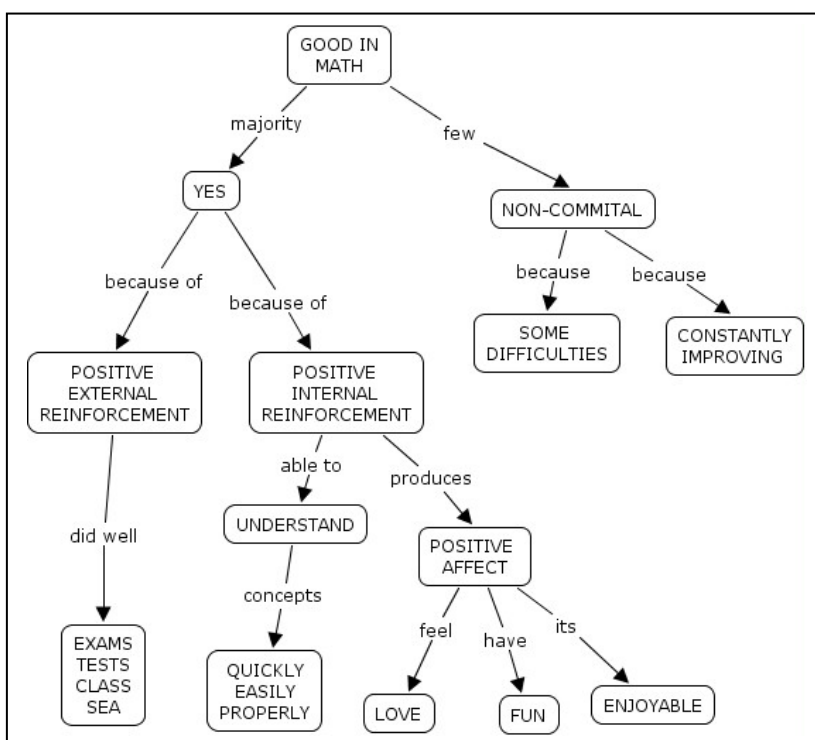
Another set of views links one's ability in mathematics with one's affect for the discipline. Students responded that they viewed mathematics as being "fun" and "enjoyable" or something they "loved" and they attributed their positive self-concept to these affective responses. This ties in with the views expressed above. All three of these views can be found in the statement below.

Yeng: I do consider myself good in mathematics because I get really high grades in the subject, I

understand everything in a short period of time and I enjoy doing this subject because it is my best subject.

In this example we see that the three themes are interrelated and integrated into the individual's mathematical identity. Prior success, personal knowledge and positive affect all contribute to creating a positive image of one's mathematical ability.

Figure 6.5: Concept Map of students' conceptions of their mathematical ability



Understanding math

Most students view their own mathematical understanding positively. For Lillian though it is not, and she says, “I don’t find math easy to understand. It is so because of all the complicated rules involved.” Here Lillian does not suggest that she cannot understand and is not able to do mathematics, but rather that it is the mathematical rules themselves that are mysterious or incomprehensible. Other students express a similar sentiment that mathematics is generally easy to understand with the exception of some

areas. For Allison, problem solving often involves locating “clue words” while Tara suggests that “there is always a trick in it.” This particular prior discourse regarding clue words is an important one and I will expand on it in the section below on students’ conception of learning/doing mathematics.

The majority of the responses suggest mathematics is an understandable discipline for these students. As students elaborate, their answers reveal links to other conceptions and discourse models. For example, responses, such as Gertrude’s, “I think mathematics is easy to understand if you pay attention,” and Antonia’s, “I really find mathematics is easy to understand because I listen carefully to the teacher’s explanations, then translate it into my own words, making it easier for me,” reveal that their own understanding is tied in to conceptions regarding mathematics teaching. Others such as Parvati, “I find mathematics easy to understand because I pay close attention in class and revise my work” and Victoria, “Mathematics is easy to understand once you study and discuss the work examples until you understand the concept” show students taking an active role in their own understanding and is linked to conceptions regarding the learning of mathematics. These and other similar statements suggest that understanding mathematics is seen to be an effortful, active process by the individual student that involves other social agents, particularly the teacher.

Other responses link students’ ease of understanding with their conceptions of mathematics as a domain, specifically, the view that mathematics is a collection of basic rules/operations and brain based as the following examples illustrate:

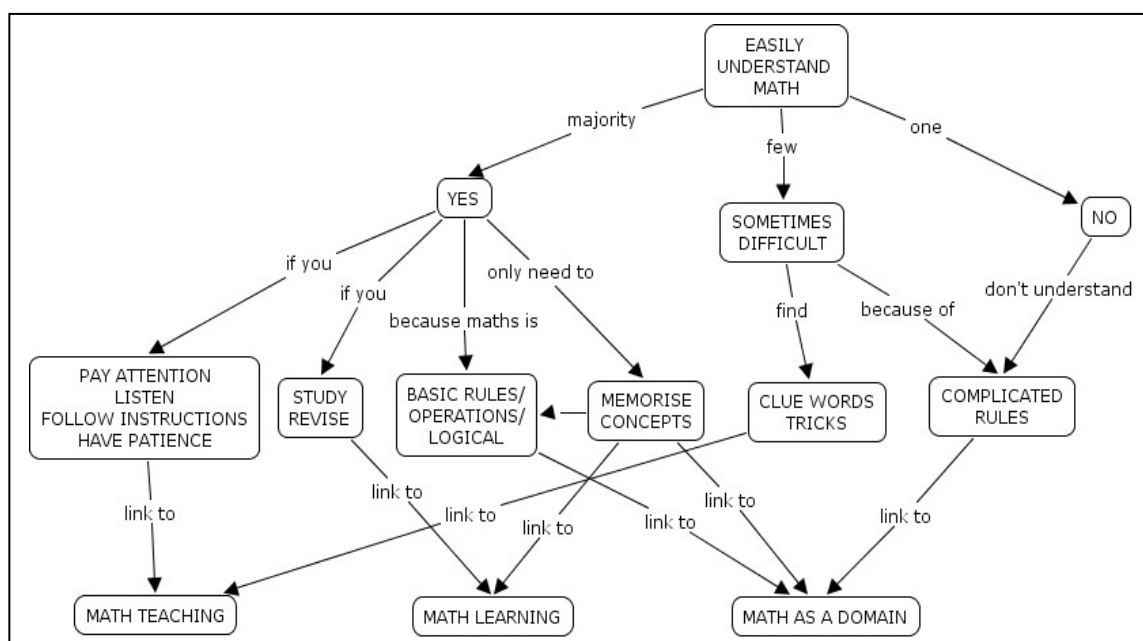
Elizabeth: Mathematics is very easy to comprehend because it is basically about the four operations and the application of these operations.

Naobi: All you have to do is memorise the concepts.

Nadine: I find mathematics is easy to understand because everything is based on logic.

Students view of mathematics as a set of rules based on numbers and the four arithmetic rules which has been discussed above helps to explain these responses. Naobi's statement that all you have to do is "memorise the concepts" is linked to discourse models relating to the learning of mathematics.

Figure 6.6: Concept map of students' view of their mathematical understanding.



Students' self concept in relation to mathematics is cross-linked to other discourse models regarding their conceptions of mathematics as a domain, mathematics teaching and learning. Their mathematical identity is a synergistic combination of their involvement in prior discourses relating to academic success and rewards, their views of mathematics teaching and learning and their views of mathematics itself.

Learning and Doing Mathematics

In the previous two sections I have examined students' discourse models of mathematics as a domain of study/discipline and their perceived relationship to

mathematics. In this and the next section I will examine how these relate to the views that students have of mathematics learning and mathematics teaching. In this section I focus on the former – mathematics learning. The responses to six questions from the questionnaire constitute the initial data. These questions were, ‘*What should one do in order to learn mathematics?*’, ‘*What are the most important things in doing well in mathematics?*’, ‘*In your opinion what skills do people who are good at math have?*’, ‘*Can everyone do mathematics? Why or Why not?*’, ‘*What do you think about mathematics homework? Is it easy? Difficult? How long does it generally take?*’ and ‘*How have you used a mathematics textbook to learn mathematics?*’. These questions are inter-related and several cross-question themes emerged.

Paying/Being attentive

One of the major themes that emerged from student responses to the questions of learning and doing well in mathematics was the necessity of “paying attention” to the teacher in class. Students linked this to the requisite skill of being able to “listen properly and attentively.” The importance of being able to pay attention was also linked to the ideal classroom environment which several students suggested should be quiet so that they could “hear” the teacher. Again this is tied in to the discourse model relating to teachers and teaching which forms the subject of the penultimate section.

For students, attentiveness is directed towards what the teacher says and does as the following remarks illustrate:

Cerise: One should pay attention to the teacher when she is speaking

Cynthia: One should listen to their teacher very attentively...

Antonia: I think one should give her undivided attention during class times so that she understands everything the teacher says.

Nadine: In order to learn to mathematics one should pay attention and try to understand what steps are being taken and why.

Teacher speech and action are thus seen as very important in learning and doing well in mathematics. The word “paying” is also instructive since it suggests that students do not see themselves as passive recipients of the teacher’s knowledge. In order to learn and do well in mathematics they ‘invest’ their attentive energies in paying attention to the teacher. The expected return on their investment is “understanding” as Antonia and Nadine’s statements above suggest.

Understanding

Understanding is a major concern for these students. It is posited as one of the most important things in doing well in mathematics and is linked to several skills that students suggest are important in being good at mathematics. Understanding is both an individual as well as a social activity. As discussed above one of the expected outcomes of students’ investment of their attention is an understanding of what the teacher is saying and doing and why. Student responses indicate that ‘what’ is to be understood refers to “specific problems”, “steps”, “the work”, “the concept behind it”, and “the basic points.” In these, understanding is a destination or a thing. This is related to a conception of mathematics as received rules and operations with an emphasis on cognitive skills such as memorization. However, several students also view ‘understanding’ as the process of coming to know and this is reflected in their emphasis on understanding why and how. Nadine’s statement above for example, is typical of this in that one must “try to understand,” i.e. one actively works at the process of understanding. In her case (and a few others) though, understanding is both the journey as well as the destination.

Seeking assistance

Paying attention, understanding and seeking assistance, form a triad of related activities that students view as important in learning mathematics, as the following examples illustrate:

Cerise: One should pay attention to the teacher when she is speaking and if they do not understand ask questions.

Tara: One should be very attentive and hardworking and must try to understand the problems if they don't understand, you can ask your teacher.

Students' awareness of their own lack of understanding following their attentive investment and their desire to understand elicit learned, help seeking behavior in which the teacher serves as the primary resource. Similar findings have been found by Amit and Fried (2005) who observed that students reported a hierarchy of expertise from teachers, to parents, to friends and textbooks. Help seeking behavior is also described in the literature as an important self-regulatory strategy (Newman, 2002). Students expect a payoff in understanding following investment of their attention. When they do not immediately receive this return they seek a more direct means to achieve this end by asking for assistance from the teacher. Both students' attention and the teacher's attention can be seen as important 'social goods' in the classroom. For teachers, students' invest their attention with an expectation of a return in understanding/knowledge. This attention then is not something to be taken for granted by teachers. For students, the teacher's attention is important when one does not understand. Thus, the degree to which one is able to access this social resource is seen by students as directly affecting one's understanding and ability to understand.

Revising/Practicing/Studying

Learning and doing well in mathematics requires effort on the part of students that goes beyond being attentive in class. Understanding as both ongoing process and finished product is achieved through continuous revision for these students. The ethic of these students is one of consistent work:

- Xumei: One should revise your day's work everyday, pay attention to your teacher and if you have a problem always raise your hand and ask for help
- Jasmine: One should practice a lot of the problems in order to learn mathematics.
- Ivanna: The most important things are paying attention, doing homework and studying the definitions when you come home.
- Victoria: The most important things in doing well in mathematics is the more a concept is applied, the clearer it becomes and more practice in working out examples is an essential ingredient to success.

Daily revision, practice with examples, completing assignments, working on one's difficulties and studying are not perfunctory for these students, instead they view them as integral to learning and succeeding in mathematics. The responsibility for learning and understanding is viewed as being shared between the teacher's efforts in school and the individual's effort at home. Again, it is not unreasonable to surmise that these are activities that these students have engaged in the past and which have brought them academic success thus far.

Mathematics homework is an important part of the process of revision and improving or clarifying understanding. For example, Elizabeth states that, "I think mathematics homework is absolutely necessary because it is a way in which one can revise mathematics" while Francine describes the relation more clearly, "I think that homework is very useful so that if we didn't understand the work during classtime you

will learn it at home.” The mathematics textbook provides the central resource for revision, practice and deepening understanding of mathematics.

Problem solving skills

One’s ability to understand and do mathematics well is supported by a set of problem solving skills. This view is linked to students’ conception of mathematics as solving problems/problem solving discussed earlier. Among these skills are basic numeracy (counting, times tables) and computational efficiency which emerge from a conception of mathematics as calculation and a collection of (arithmetic) rules/operations. In addition many students view the ability to work quickly and mentally as important skills which supports their views regarding the link between mathematics and the brain expressed earlier.

Other sets of skills seem more closely aligned with students’ emphasis on and valuing of understanding. One of these skills is reading. For example, Francine writes, “In doing well in mathematics you need to be able to read properly and to grasp what the question is asking, also you need to have a knowledge of adding and subtracting.” “Reading properly” and “grasping what the question is asking” are comprehension and decoding skills. The adverb “properly” suggests that there are correct (and incorrect) ways to ‘read’ problems. Understanding then is tied up with the proper decoding of the wording of a problem. Other references to proper reading include “interpreting” and “analyzing” questions. All of these point to a concern with the language of problems. As we observed previously, students view mathematical problem solving as involving the location of “clue words,” “key-words” or figuring out the “trick” in the problem. Naobi, for example, writes about, “the ability to recognize alteration made in the way something

[is written]” as an important skill while Sephra suggests that “following the key words” is important in doing well.

The mathematics education literature also refers to students’ use of clue words or key words as a strategy employed to decipher what to do when presented with word problems in mathematics (Clement & Bernhard, 2005). In this way students are able to proceed to work out a problem without a deep understanding of what is being done or why. I wondered whether these successful students had also been exposed to this particular aspect of mathematical discourse given the nature of some of the responses to the questionnaire. Thus, I examined this in some of the interviews. The excerpt below is taken from one of these (S.I.2).

- I: ...so on your questionnaire you said that some problems you have to get the clue words and many others, what do you mean by that? The clue words? 127
- Allison: Like you have to take out like the numbers and like when they mean like take away and like put together and find out and... 128
- I: And where did you first hear that? Clue words? 129
- Allison: My teacher, Miss Z, she used to be like, she used to real take her time and teach us, and she used to tell us, the first thing we had to do was find the clue words and then we have to put it together and then we have to work it out and then we have to get the answer and then we have to put the units. 130
- I: How about you all? You ever heard that term clue words? 131
- Aaliyah: Yeah, real plenty, ever since I know maths I probably hear clue words from my parents and my teachers and the clue words are like the words that actually give hints as to what to do. 132
- Jane: And since you is have things that worked out already that not relevant to the question you like look at what you need to find that’s the clue words. 133
- Naobi: As I said in my questionnaire, maths is about simple concepts right, and like the concepts

are twisted and disfigured to like confuse us, but the clue words indicate exactly what we have to do. And like guide us so we would not like be confused and we would know exactly what to do. 134

From this episode we observe that clue words indicate to these students what operations to perform, supporting the conception that mathematics is about operations and a view of mathematics as mystery or puzzle to be solved. Identifying clue words then is the first step in solving problems according to Allison. For Aaliyah and Naobi they are the route to understanding what needs to be done. In the types of problems to which these students have been exposed thus far, identifying and responding to clue words form an important and successful strategy in problem solving. In addition this excerpt reveals the influence of some of the socio-historical voices that are not explicitly presented in this thesis – the voices of parents and previous teachers. Understanding as process and product, destination and journey, is aided by being able to correctly identify and follow the clue words in questions. Clue words are an important element of these successful students' prior discourse. The excerpt above also provides a contemporary example of Love and Tahta's (1991) historical analysis of the word 'problem' in mathematics education discourse as both "a question that could not be answered by straight reproduction of a learned method...[and] a question that involved a tricky use of known procedure or some unexpected insight..." (p. 264).

Attitudes

In addition to paying attention and working at understanding students also express that certain attitudes/dispositions are necessary to learn and do well in mathematics. Some of these characteristics include "patience," "dedication" and "ambition", which are congruent with the ethic described above of consistent work. Confidence in one's own

ability, excitement, a willingness to learn (motivation) and a positive outlook are also mentioned as being important to learning and doing well in mathematics. Finally, students also suggest that one must have a love for the discipline in order to do well.

In summary, students' discourse model of learning mathematics places a heavy emphasis on paying attention to the teacher, revising frequently, knowing when to ask for assistance, learning basic rules, actively working at understanding the material, using problem skills such as clue word deciphering and adopting a positive attitude and motivated mindset.

Doing Mathematics

In response to the question of whether everyone could do mathematics, the majority of students responded positively that everyone could do math either because "it's simple" or required effort and attention. This is likely linked to their view of mathematics as a domain largely about calculation, operations and problem solving. Another reason given was linked to the view that mathematics is important and a part of everyday life. However, I was intrigued by the reasons given by students for saying that *not everyone* could do mathematics. Several students bring into the discourse the view that social inequalities and lack of opportunity may hinder one's ability to achieve in mathematics.

Priscilla: Not everyone can do mathematics because not everyone can afford to go to school.

Rita: No some people cannot do maths because they never had the chance to go to school.

Cerise: No everyone cannot do mathematics because some children aren't fortunate like others and they might not have a chance to receive an education.

This is one of the very few statements where students acknowledge the benefits of education and schooling in general. In addition to the inability to access educational

opportunities, students also suggest that some persons develop “mental blocks” to mathematics or because of inattentiveness are unable to understand mathematics and thus are unable to do it. Others recognize that some students might have different mental abilities when it comes to learning mathematics. A few suggest that there are some concepts that not everyone can grasp and that mathematics is a skill that one must learn.

This question provides interesting insight into what students view as necessary for being able to do mathematics. Clearly, individual effort and teachers play important roles, but there is also an acknowledgement that not everyone has equal opportunities to learn mathematics.

Textbooks and homework.

Rena: I have used a mathematics textbook to learn mathematics by reading, understanding and practicing instructions, examples, theories, concepts and exercises.

Cynthia: I have used a mathematics textbook to learn mathematics by doing exercises which help you to get practice and by reading the examples which are given which helps you to understand it better.

Victoria: In the mathematics textbook I looked at the formulas and began using the formula to solve the problems. I also followed the examples which was of great help

Mathematics textbooks and homework are ubiquitous and important features of the educational landscape. Students use their textbook mainly as a source of revision/practice questions as they work at “understanding” or “reinforcing” their knowledge. The majority of students report reading examples, explanations or formulas from their textbook. Linked to reading is the idea of mimicry, as students follow models of how to write their responses and the sequence of steps to follow. It is a tool which plays a utilitarian role in these students’ attempts to understand and do mathematics.

Few students find mathematics homework difficult and only one explicitly states that she finds it difficult. The majority find it easy upon the condition that one has understood the work. Some find it easy because they enjoy doing mathematics in general while others state that it is sometimes challenging. Again, completing homework is linked to students' study ethic and their attempts to understand mathematics. In terms of the duration of time expended on homework, responses range from a few minutes per problem to a maximum of ninety minutes. The majority of responses put the time somewhere around thirty minutes. Students' conceptions of what learning and doing mathematics involves, is summarized in the concept map below (Figure 6.7).

Mathematics Teaching

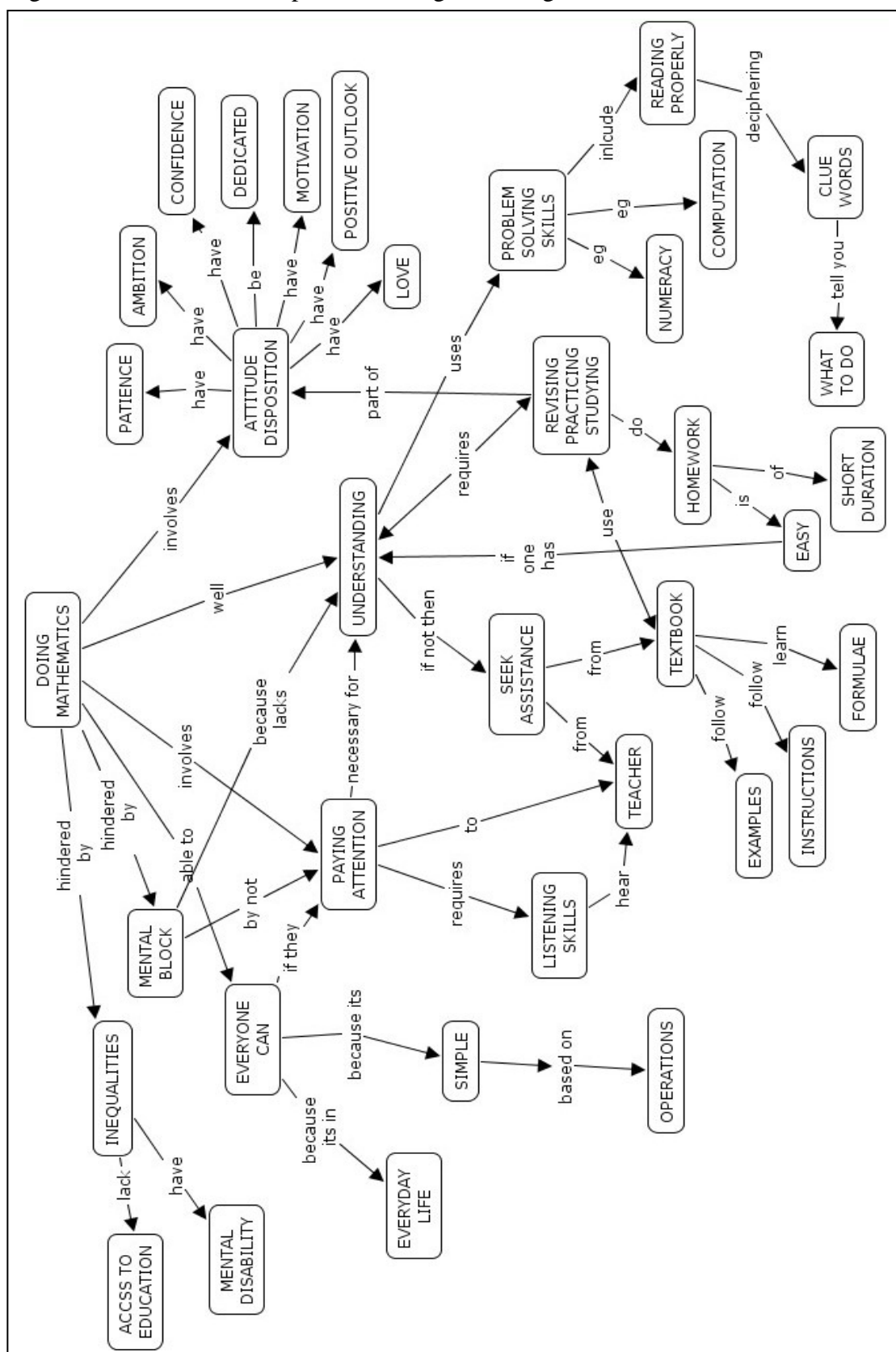
In the preceding sections students have described their view of mathematics as a domain, how they see themselves in relation to mathematics and what learning and doing mathematics entails. The importance and significance of the mathematics teacher is a theme that spans all of these. In this section I examine how students view mathematics classes in general and mathematics teaching in particular. Three questions as well as interview excerpts constitute the data for this section. The questions were, "*Describe your typical mathematics class*", "*Describe your ideal mathematics class*" and "*What do you think are the characteristics of a good mathematics teacher?*"

Mathematics Class

Students' mathematical activities in school are structured by their teacher. Thus students come to view mathematics class as a sequence of activities initiated by the teacher in a fairly predictable and stable pattern as the following examples illustrate:

Jane: My typical mathematics class would be listening to my math teacher and taking notes, referring to the textbook for both information and exercises.

Figure 6.7: Students' conceptions learning and doing mathematics



Cerise: In maths class, our teacher usually talks a bit about the topic we are being taught on and after she shows us examples to which we follow and after that we get an exercise.

Nadine: In my typical mathematics class the teacher would first talk a bit about the topic being taught, teach us how to do it, while explaining the logic behind it and then give us work based on the topic.

The sequence of events in a typical class begins with students paying attention (listening) while the teacher explains the material (teaches/gives notes). This is followed by worked examples (showing) which students follow (to understand). Next, the teacher assigns problems for students to practice (exercise). Finally, these problems are corrected and explained (evaluated). In this model the teacher's task is to explain while the students' task is to understand. This fits with the transactional model of learning and doing mathematics described above. This is a very stable discourse and is an already internalized model of how a mathematics classroom/lesson typically unfolds. Again, that these students come from different primary schools suggests that this Discourse is pervasive. That this model of classroom teaching has been partially responsible for their success in the recent past may act to reinforce the view that this type of teaching is the best way to teach mathematics. In the next chapter I suggest one way in which this sequence is reinforced via the authority of the teacher and the textbook.

There are aspects of this model that students do not like. Note calling is one of these. Xumei, for example writes, "In mathematics I dislike when I have to write a lot of notes and quick jottings." This sentiment is echoed by Tara who states, "...if I would like to change anything it would be all the notes there is to take down." This feature of a typical mathematics class then may result in negative affect for these students during class. In addition Lillian is concerned with being able to do the exercises assigned but

not fully understanding how she is able to do them. This response is problematic given that many students are likely able to complete exercises and thus demonstrate competence without an understanding of what they are doing.

In responding to what they saw as an ideal mathematics class a more diverse set of conceptions was elicited that reflected students' desires. The teacher's role is still pre-eminent in the class but the language and emphasis in the responses suggest that a different *type* of relationship than is found in the typical class is desired.

Elizabeth: My ideal mathematics class would be a class where students get together with the teacher and discuss a certain topic. The teacher should clearly see how the student arrived at his/her answers.

Naobi: My ideal mathematics class is one where student and teacher are able to interact in a mature orderly manner for the enlightenment of all.

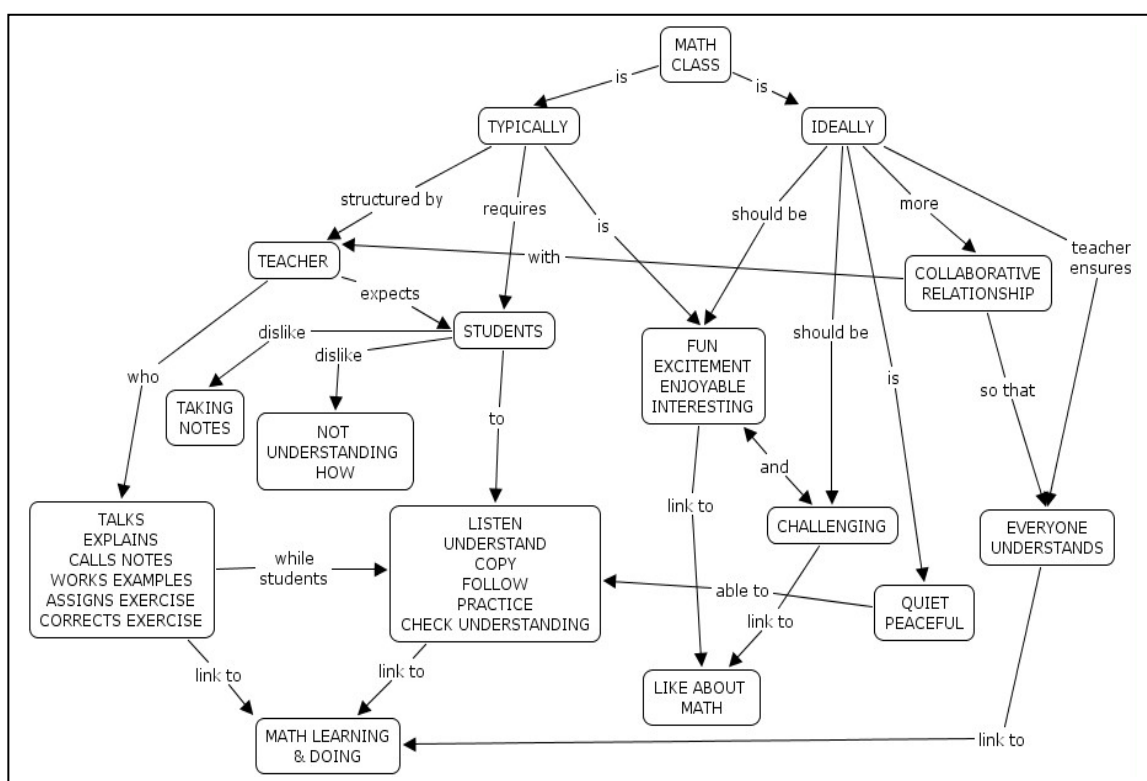
Nadine: In my ideal mathematics class the teacher would explain the topic and continue going through it until she/he is sure the student understand and then he/she would let the children do similar sums in case the children were too shy to speak up about not understanding, then the teacher would calmly re-explain as many times as needed.

In an ideal class Elizabeth and Naobi seem to be asking for a greater degree of autonomy as well as an expanded relationship with their teacher that is at its heart more democratic, social and collaborative than in the typical class. In desiring a more intimate relationship with the teacher as well as a concern for the progress of other members of the class, as Nadine and others express, we see that their ideal class is also highly social.

Many students describe their typical and ideal mathematics class in terms of how they 'feel' about it as opposed to what they do there. Students describe their typical and ideal class in affective language such as "interesting," "enjoyable," "fun," "passion," "exciting" and "challenging." For example, Parvati writes, "[m]y ideal mathematics class

must be interesting, challenging and enjoyable.” Thus, ideally mathematics class should balance fun, excitement, and interest with a manageable level of challenge. The teacher’s activities are identified as a source of these feelings as Michelle writes, “My typical mathematics class is fun cause my teacher makes the class interesting.” Mathematics class may also be viewed as fun as a result of the positive affect that these students have for mathematics in general.

Figure 6.8: Students’ conceptions of a typical and ideal mathematics class.



Mathematics Teacher: Patient, Knowledgeable, Understanding

Mathematics teaching and consequently one’s mathematics teacher plays an important role in shaping one’s conceptions of mathematics. Thus, an important aspect of students’ discourse model is the characteristics that they ascribe to ‘good’ mathematics teachers. Students identify several such characteristics which include both personal as well as professional attributes.

Patience

Patience is among the most important personal attributes of a good mathematics teacher according to the students. Teaching with patience is also linked to another major characteristic – teaching with understanding. The following examples illustrate this link:

- Elizabeth: When a student needs individual attention, the teacher should have enough patience to explain the topic.
- Jane: Will take time to explain a new topic and make sure you understand it well before progressing on to another topic and will make time to revise before tests and will be patient with a student who does not fully understand.
- Nadine: A good mathematics teacher must be patient must capture the children's attention must be willing to explain and give as much examples as needed until he/she is sure that the students fully understand.

Patience is important to students as they work at understanding. A teacher who is patient takes or makes time to explain the topic to the class as a whole, providing sufficient examples ensures that all students understand the material before proceeding to the next topic and before assessing learning. A good teacher is also patient with individuals and willing to work with them to ensure their understanding of the material. Thus, a patient teacher ensures that no one is left behind. Associated with patience are other personal attributes such as being approachable, compassionate, kind, open-hearted and dedicated that speak to the type of relationship that students desire with their mathematics teacher.

Dedication was a term that was not used by many students and I was unclear what students meant by this description. I asked about its meaning in a subsequent interview (S.I.3).

- I: And also yes you talked about the characteristics of a good mathematics teacher, one of the characteristics that you had was dedication, what do you mean by dedication? 44

- Cynthia: That they like the children and they have the ability to teach the children and make sure they understand the work. 45
- I: What do you all make of that? 48
- Katija: Well I think that a good mathematics teacher will make sure that the children understand the work and explain it over and over until they get it right. 49
- I: What do you mean by dedication? That's what I'm trying to understand? What do you mean by dedication? 50
- Xumei: Make sure that the children understand the questions...and they are...not like lost in any of the questions and the teacher knows that they need help. 51
- Jasmine: The teacher wouldn't just..., if you don't understand something she wouldn't just leave them just so and go on to teach another topic. She would explain that one and help them understand it and she would make sure they understand it, give them problems, help them to practice it and stuff. 52

The concern with having a patient mathematics teacher is tied into the view of dedication and is linked to students' understanding of their own need for time and assistance in understanding mathematics. Their comments also reveal that they are motivated to learn mathematics and sometimes require more time than is allotted to understand fully. They also seem to be expressing a view of prior experiences that they have had or observed in mathematics classes, that sometimes teachers leave students behind who do not understand. Being left behind in a state of not understanding seems to be a palpable fear that students have regarding mathematics teaching and learning. Finally, students seem to be expressing a desire for a form of relational intimacy with their teacher as described by the characteristics of compassion, kindness and approachability. A dedicated teacher is patient as well as kind. They desire not only knowledge and assistance from their teacher but also a degree of love and emotional security. This is what Noddings (2005) has termed a "caring relation."

Knowledge

The second characteristic of good mathematics teachers is that they should be knowledgeable. This knowledge includes command of mathematical content and problem solving as well as a mathematical pedagogy that is engaging and makes learning mathematics pleasurable.

Lillian: ...knowing how to solve mathematical problems correctly. By knowing the rules of everything...

Michelle: I think the characteristics of a good mathematics teacher is that she/he must know everything about mathematics and must know how to explain the sums so that the children could understand.

Antonia: I think a good mathematics teacher has to be interesting...and a way to catch the class's individual attention without much trouble.

Students' view of teachers' mathematical knowledge is linked to their view of mathematics as a set of rules to be learnt towards an end of solving problems. Teachers as the main mathematical authority in the classroom are thus expected to know all the rules and know the "correct" ways to solve problems. In addition, because students' attention is something that they invest with an expectation of understanding and positive affect, they are also desirous of a pedagogy that is simultaneously effective and stimulating. Mathematics teachers' pedagogical approach to their discipline can be a source of fun, excitement and pleasure or of frustration and anxiety for students.

Understanding

Understanding is a theme that is linked to a number of different conceptions explored in this chapter. Students pay attention and work consistently in order to understand mathematics. Such understanding is both relational as well as instrumental (Love & Tahta, 1991), i.e. knowing what to do and why as well as how. A good teacher

then is one who teaches in such a way that students can understand the material easily. However, understanding is also used to describe the *character* of a teacher who is able to appreciate students' difficulties and adapt their teaching to help students to overcome these difficulties. This view is linked to the characteristic of patience and dedication described above. Understanding is also linked to effective communication, empathy for students and being able to explain well. The following examples illustrate this diversity.

Xumei: I think the characteristics of a good mathematics teacher are to be able to work questions in an understandable manner and to be able to interact with the students.

Allison: Being able to not only know mathematics but to use that knowledge to communicate with his/her students effectively.

Ivanna: I think the characteristics of a good math teacher is being able to teach in a way that students can understand and the teacher must be able to understand and help the students.

Students see themselves as struggling both to understand (mathematics) and to be understood (by their teacher). Good mathematics teachers, through their communicative acts, successfully address both of these needs. They make themselves (and mathematics) understood and they themselves are sensitive to the difficulties that students are having. They have the capacity (knowledge) and disposition (patience) to ensure that all of their students understand. These conceptions are summarized below (Figure 6.9).

Saraswati's Mathematical Discourse Models

In this section I will examine Saraswati's espoused discourse models of mathematics along the same dimensions used above. I will also compare hers with those of the students. Saraswati was unable to complete the questionnaire at the same time as the students, and instead we incorporated the questions into the final on-site interview (TI6) which constitutes the data for this section. As students' discourses create and are shaped by their identity and position as student, so too is Saraswati's linked to her

Saraswati's orientation is to view mathematics as the process of solving problems using different methods which make logical sense. This is very similar to the students who also view mathematics as sets of rules/operations utilized in solving problems. For Saraswati, problem solving is a process of reasoning, of coming to understand why and arriving at a final (correct) answer. Her statement also provides insight into her pedagogical orientation in that she is welcoming towards students' contributions and explanations and does not see herself as the sole mathematical authority in the classroom. She also reveals that over time she has come to appreciate that there are different ways to solve problems that are equally valid and equally correct.

Like her students, Saraswati also sees mathematics as important for everyday life mainly in the form of consumer arithmetic. However, as a teacher she expresses reservations that some of the more abstract areas like algebra are much more difficult to "see it being used in the outside world." Saraswati also finds some topics more enjoyable to teach than others. This sentiment comes out in the excerpt below (T.I.6) as we discuss what she likes and dislikes about mathematics.

- Saraswati: Personally, the only thing I like about mathematics are the topics that we do in form four and form five. Other than that, honestly from form one to three I hated maths, I mean I used to do horribly... 70
- I: Why you hated maths? 71
- Saraswati: Cause I had a horrible teacher or teachers. 72
- I: Well that's my second question, what do you dislike about mathematics? 75
- Saraswati: Well now I actually like the topics but I find that in form one you have to go back to basics and to me, personally, I don't ever remember learning things that I did,...that I have to teach now. I doh remember learning bases, I doh remember learning how to find prime numbers, composite numbers, to me I just knew that. I feel as if I was just born

with it. I don't remember being taught it. To have to go back to explain basics is just kind of hard.

76

What these responses suggest is that for Saraswati mathematics is viewed as a discrete sequence of topics that she is required to teach, many of which she finds personally unfulfilling to teach in the lower school. Her own experience is one of “hating” mathematics because of “horrible teachers” at this level. She struggles with the dissonance between the topics that she has to teach and her inability to recall being taught those things herself. Her inability to recall learning some of these topics is part of her internalization of her own prior mathematical discourses. These are things that she has always known; they are an essential part of her identity and, as such, she is uncertain how to proceed to teach these topics. They suggest that for Saraswati mathematics is something that is taught, learnt and remembered as well as something innate. The excerpt also points to how Saraswati sees herself in relation to mathematics and mathematics teaching, a theme that I explore below.

Saraswati's Self in Relation to Mathematics

When Saraswati says above that “to have to go back to explain basics is just kind of hard,” there is melancholy in her voice. Her language also harbors a sentiment of personal frustration at being compelled to “go back.” The source of this compulsion is external. It lies in the topics to be taught. Anxiety and fear accompany her lack of control over this aspect of her teaching and emerge from her sense of uncertainty regarding how these topics ought to be taught. By casting the topics as “basic” Saraswati positions them as foundational and common mathematical knowledge that students ought to know. In addition she locates herself as being in an advanced position relative to these basics. In this way she is able to protect her identity as a mathematics teacher and

preserve her relationship to mathematics. As a mathematics teacher Saraswati's mathematical self concept is intimately linked to her professional practice as the following excerpts (T.I.6) illustrate.

I:	Do you consider yourself good in mathematics?	108
Saraswati:	[looks uncertain] Um...hmmm...not as good as...well, not really.	109
I:	Why?	110
Saraswati:	I dunno, probably up till like form five level, probably even form six, but umm, you know, I doh really think after that I am too good at it. And I think it's probably because of the teachers I had in UWI, they weren't very good.	111
I:	Do you find mathematics easy to understand?	116
Saraswati:	Um, well, for the levels that I teach now, yes it is, um...yeah, I could pick up a maths textbook and the things in it, the examples, the explanations and stuff actually make sense to me now.	117
I:	What do you think then are the characteristics of a good mathematics teacher?	83
Saraswati:	Well, [half-jokingly] obviously not me. But um, I think a good maths teacher should be able to target you know the intelligences of everybody in the classroom.	84

This was not the first time that Saraswati had been self-deprecating in our interviews. She feels competent and comfortable, though at times uncertain, in teaching mathematics to students below a certain level and sees mathematics done in the higher classes and university as something she is not too good at. She attributes this partially to her mathematics teachers at university. This, and her previous statement regarding why she hated mathematics in form one to three, indicates her understanding of the relationship between one's mathematical experiences, one's mathematical self concept and one's affect for mathematics. It reminds her that good mathematical pedagogy is not the same as good mathematics and informs her pedagogical goals which are discussed below.

The mathematics that she teaches is understandable, however the statement that “it makes sense now,” also points to a time when it did not make to her sense prior to her beginning her teaching career. In addition, she defers to the mathematical authority of the textbook in helping her to understand what, and possibly how, she has to teach. Teaching then is part of her current motivation for understanding mathematics at a deeper conceptual level. However, later in the interview when we are discussing why a particular method works she says, “I just believe that mathematicians many years ago, they proved it.” This is another authoritative discourse in which she positions herself as the recent recipient of knowledge from a mathematical authority in the unquestionable (and unreachable) past. Saraswati sees herself in an uncertain relationship with mathematics. Some areas she knows innately but is uncertain how to teach these to students while she lacks confidence in her abilities in other areas which she attributes partly to her past teachers.

Mathematics Learning and Doing

Saraswati’s model of learning mathematics, like the students, emphasizes attentiveness to the teacher in class, revision and practice at home. She too views students’ learning as an active process which requires students’ investment of their attention in class and diligence at home to complete assignments. For Saraswati homework is important both as a means of reinforcing the day’s lesson and as a form of assessing one’s own understanding. The following excerpt (T.I.6) illustrates these ideas.

- | | | |
|------------|---|-----|
| I: | ...how does one learn mathematics? | 98 |
| Saraswati: | Well I guess, paying attention, if they could, and personally I always thought homework was very important. | 99 |
| I: | Why? | 100 |

Saraswati: Because, you know, your teachers always, well when I was in school, your teachers always said, 'go home and learn what you did for that particular day'. But with maths its kinda hard to sit down and read what you did for that particular day, so obviously when your teachers give you questions you know from that particular class, it would be questions based on what you did, and you know, if you do it, it will help reinforce, or it will actually let you know what you don't know. 101

Paying attention and homework are two keys in this discourse model. For students their efforts are rewarded with understanding, for Saraswati her reward is students' gaining mathematical knowledge. In the next chapter I will look at this emphasis on homework. Additionally, in this excerpt we hear Saraswati's re-voicing of her prior teachers and their prior discourses. Although not explicitly stated above, there seems to be an expectation that when students do not understand the material that they will seek assistance by alerting the teacher. It is also implied that students are able to assess their own level of understanding of the material by doing questions.

In responding to the question of what things students need to do well in mathematics Saraswati moves away from attention and understanding of mathematics and focuses on performance in terminal exams. Thus, for Saraswati, doing well in terminal exams is equated with doing well in mathematics.

I: What are the most important things in doing well in mathematics?...Things that you need to do to do well? In addition to what you've just said... 102

Saraswati: um, well in form one, I am thinking more like form fours and stuff...[looks slightly confused], past papers you know, um... 103

I: Why past papers? 104

Saraswati: [laughing], CXC past papers all the questions repeat themselves, so and the classes that I have, I think if they keep doing past papers as soon as we finish a topic and they go and they do the particular question in the past paper related to that topic, after a while they'll

get the hang of it, they'll have an idea of how the question comes, so that for a real exam, I dunno, a mock exam, or a final exam, they will not get scared, cause a lot of them get scared when they see a math paper, you know they wouldn't get scared and forget everything that they did. 105

Although she does not employ the phrase clue words or tricks as the students do, Saraswati's emphasis is on students learning "how the questions come" since "all the questions repeat themselves." Thus, in order for students to do well in mathematics they need to obtain sufficient practice and familiarity with the types and wording of questions that they will encounter in these exams so that they will better manage the emotional anxiety associated with the exams. Doing well in mathematics does not just imply knowing or understanding mathematics but also for Saraswati, learning test-taking strategies including affect management. Past-papers provide a means to help students learn how "to do *well*" in mathematics. The Discourse in which she is involved is assessment driven. Student success in terminal examinations signifies learning and thus good teaching. Doing well in mathematics is not the same as learning or understanding mathematics, but instead combines this with important test-taking strategies which are in part dependent on learning the language of an examination Discourse which is fairly stable.

Saraswati also expresses a belief that everyone can do mathematics but that this depends on how it is communicated by the teacher. Recall that for students as well effective communication by their teacher formed an important element of their coming to understand mathematics. She draws on Gardner's multiple intelligences as well as the vision of the SEMP syllabus where a similar sentiment is stated explicitly (see Appendix C)

- I: Can everyone do mathematics? Why or why not? 81
- Saraswati: I think everybody could, I believe in the whole SEMP syllabus, their basic vision, well, their thought process behind the whole syllabus is that everybody could learn and it's just some people learn differently. Some people can have a teacher stand up in front of a classroom and talk non-stop, write on the board and they'll understand, some people will be able to look at things visually and then they'll understand, you know, depending on their multiple intelligences. So I think everyone can learn maths it depends on how it's being brought across to target their multiple intelligence. [shrugs] 82

Saraswati buys into the discourse of the SEMP vision that “everyone can learn.” In addition she links this vision to the educational Discourse of Gardner’s Multiple Intelligences. Again, she speaks here with others’ voices (and words). For Saraswati these seem to be internally persuasive discourses. However, they are problematic for her teaching identity since if everyone can learn mathematics and this depends on how it is being taught, then if students appear not to be learning it must mean that she is not able to target their appropriate intelligence.

Students’ abilities

Saraswati also holds beliefs and expectations regarding the abilities of students attending schools like the one in which she teaches. This is based on her past experiences teaching this level as well as her immersion in wider societal Discourses. These beliefs come out in our discussion of the mathematics text and the syllabus that she uses (T.I.1).

- I: The text that you all were using is it the same one you were using last year? 16
- Saraswati: Yeah. 17
- I: What do you think about the text? 18
- Saraswati: Ummm, okay basically, the text is...ummm, the topics in the text are basically topics that they would have done in primary school. Now to a point it is helpful to be revising and that kind of thing but at the same time there are other topics like multiplying fractions,

- fractions, addition of whole numbers which I think they would have mastered by now and I realize from teaching past from ones that umm they get bored of doing that they feel as if ‘Ooh I am still in primary school’ you know, and you know ‘now that I have moved on to secondary school I want to do new stuff, harder stuff’. So it’s good for revision and it’s good for you know... 19
- I: How do you adapt or do you just continue? 20
- Saraswati: I just continue because that’s what we have on the syllabus. 21
- I: And what about the syllabus, the SEMP syllabus. 22
- Saraswati: Umm, Well the book goes along you know well with the syllabus the topics that we have on the SEMP syllabus for form one you can use the book basically straight for everything. The SEMP syllabus, I think a lot of things could be omitted for example,...simple computation, you know, whole numbers and that kind of thing their SEA exam would have tested that and if they, you know got to here, they would have been able to you know they would have mastered that skill... 23

This excerpt again provides evidence for a view of mathematics as a collection of topics. In addition Saraswati expresses her thoughts on what she believes students who have passed for this school ought to have mastered by now. Again she relies on their prior performance in the SEA exam as a justification for these beliefs. Her statement also supports the students’ views expressed above of primary school mathematics as mainly computation and calculation. She notes as well that while some revision of the primary school mathematics is useful, students have in the past expressed feelings of boredom with the material. Going by their espoused model above, we might say that they find it unchallenging.

The excerpt also links to Saraswati’s previously expressed dissatisfaction with having to go back to basics which she finds difficult. It is further evidence for Saraswati’s sense of not being in control of what she has to teach, of being unable to

mathematics in the classroom. In addition, Saraswati perhaps does not wish to be remembered as a “horrible teacher” as are her memories of her teachers at this level. Her experiences seem to support the view that having an affectionate relationship with students serves as a partial motivation for students attending and engaging with mathematics as a discipline. Attention, interest and student engagement with the subject are linked for Saraswati. These are also linked by students who posit an important motivational role for a teacher who is understanding and patient. This desire to be liked and the central role that it occupies in her teaching identity also leaves Saraswati vulnerable. I address this aspect of Saraswati’s vulnerability in Chapter 8.

The desire to be liked manifests itself in how Saraswati views her pedagogical actions in creating a learning environment for students as described in the excerpt below

(T.I.6)

- I: So describe a typical mathematics class, for form one. What do you consider a typical maths class to be like? 85
- Saraswati: Well I use just normal talking, well I rarely use the board and only if I really have to but personally I don’t think it should be like that and I know that, it’s just that I mean trying to plan fun, exciting things especially when you have a lot of periods every week, is kinda hard, but I think a typical class should be one where everyone can go away from it and say wow, I had fun and in addition to having fun they can also go on to say that I learnt something today. 88
- I: What do you think are things that make a math class fun for students and yourself? 89
- Saraswati: Um, well it’s fun for me if they are having fun, and I’m sure it’s fun for them if it’s more like, if it’s not so much like a classroom kind of setting they don’t feel as if they in a classroom but they are, you know, they just kinda relaxed, and they in a place where they see it’s more like recreation and relaxation rather than class but at the same time they’re learning... 90

Saraswati desires that her students have fun while learning mathematics. However, she voices what is a common teacher constraint, that of having insufficient time to plan these activities. Fun for her means that students are simultaneously relaxed while engaged in learning. Students too desire that their classes be fun and several are already disposed to view mathematics as a fun activity. In addition, Saraswati wants students to enjoy what they do in a relaxed atmosphere. Again this may be her reaction to her own experiences with mathematics at this level.

In responding to the question of how she views an ideal class she expands on what she would like to do to make the class more fun for the students. This includes engaging students in mathematical games and crossword puzzles. Her rationale for this is that it would be appropriate for students' developmental learning styles.

I: Why you would want these hands on kinds of... 93

Saraswati: Cause I know it will target some of the children in the class you know, and I think at their age, from one, they still, you know, they still a lot into the whole primary school kind of thinking, and... 94

I: What's the primary school kind of thinking? 95

Saraswati: You know, um, doing things, practical stuff is fun, you know, they still like to play games, they like to run around do all sorts of things, you know, I think if you give them something practical to do, something that, you know, they like, I think it would...96

Ideally Saraswati would like to be able to design and incorporate activities that would utilize students' other intelligences. However, as she has expressed above, she feels constrained by her other teaching duties and the amount of time that she can devote to this one class. There is also a suggestion that the secondary mathematics that students will be required to do later on does not require "hands on" activities, but instead, is more

cognitively oriented. In addition there is a suggestion that this sort of mathematical activity is childish.

Saraswati's Teaching Goals

In addition to being the mathematics teacher of this class, Saraswati is also their Form Mistress. Her pedagogical and professional responsibilities are thus blended in this hybrid identity. However, she espouses a number of clear goals for the class in this excerpt (T.I.1):

I: You are also their form mistress but you are also the maths teacher ummm what do you hope you would have accomplished with them by the end of the term or by the end of the year... 3

Saraswati: Okay, well as their maths teacher I would love to finish the syllabus with them. Right because remember now they've introduced the new SEMP syllabus. 4

Saraswati: And basically umm what they were supposed to do in the first year, second year and third year, form three, one, two and three basically, will be tested. If I do my part, finish that syllabus so they wouldn't be any overlap into form two or form three so they wouldn't be left behind. As a form teacher, basically I would like them to learn you know that umm, I want them, umm, to grow morally spiritually, you know ethically, cause I am their RS [Religious Studies] teacher as well. So you know. I just want them to be you know umm well mannered, you know, respectful...basically. 6

Saraswati's primary goal is to fulfill her professional responsibilities and complete the material as set out in the SEMP syllabus with the students. This goal is important to her since she sees herself as part of a continuous system with a specific role to play. That role is to ensure that students are not left behind as they progress to the higher forms. Being left behind does not mean the same thing for Saraswati as it does for the students who fear being left behind in a state of incomprehension. Rather, she is concerned that her students will not remain competitive and may compare themselves negatively with

their peers in other classes. Furthermore, her concern also extends to those teachers, her co-workers, who will be responsible for them in the future. If she is able to do her part, there will not be extra work for these teachers.

Her second stated goal is more closely aligned with her role as form mistress and her general concern for the holistic development of her students. These are not mathematical goals but relate to students' well being and social etiquette. As the form teacher of this class she sees herself as responsible for teaching these students, young women, manners, respect and moral and spiritual values.

In this final excerpt we speak about her mathematical goals for the class:

I: ...What do you want students to learn about mathematics? What do you want these students to learn by the time they've left your class? 14

Saraswati: Well basically I mean everybody wants their students to learn the concepts that they're teaching, but in addition to that I would like my students to know that whatever they learn now and in the coming years they will be using it you know to build on, you know, other math when they move on to you know other maths. Higher mathematics. Cause some of them basically, ahmm I notice with form five that ahmm when they get to form five things that they would have done in form one, two and three they would have you know forgotten about it and I think people just need to reinforce that whatever they learn in those years they would be using it you know later on. 15

In addition to conceptual knowledge, Saraswati hopes that she is able to convey to students a sense of the continuity and future utility of mathematics, especially in furthering their academic ambitions. This goal again seems to emerge from her experience teaching the higher forms where students have forgotten the basics that they were supposed to have learnt in the earlier forms. If she achieves her goal, not only will her students see mathematics as continuous and useful but whoever is responsible for

teaching them later on will not have to revisit this material and will be able to continue to build on the foundation that she has laid.

Summary

In this chapter I have examined students' and their teacher's espoused and evaluative discourse models of mathematics. These models converge in a number of areas. Both essentially view mathematics as a rule-based sequence of operations that are used to solve problems. Both posit a simple economy in the learning of mathematics in which student attention and effort at home are rewarded with knowledge and understanding. Both see the teacher's responsibility as more than the transmission of information and perceive that the consequences of mathematics teaching include not only how one comes to view mathematics, but how one comes to view one's self in relation to mathematics and, consequently, the degree to which one desires to engage with mathematics and, ultimately one's success in mathematics. The congruency between students' and teacher's discourse models is a necessary condition for the continued functioning of the Discourse of school.

CHAPTER 7

AUTHORITATIVE DISCOURSES

The authoritative word demands that we acknowledge it, that we make it our own; it binds us, quite independent of any power it might have to persuade us internally; we encounter it with its authority already fused to it. The authoritative word is located in a distanced zone, organically connected with a past that is felt to be hierarchically higher. It is, so to speak, the word of the fathers. Its authority was already acknowledged in the past. It is a prior discourse... (Bakhtin, 1981, p. 342)

It is not a free appropriation and assimilation of the word itself that authoritative discourse seeks to elicit from us; rather, it demands our unconditional allegiance. Therefore authoritative discourse permits no play with the context framing it, no play with its borders...It enters our verbal consciousness as a compact and indivisible mass... It is indissolubly fused with its authority – with political power, an institution, a person... (Bakhtin, 1981, p. 343)

In this section I acknowledge some of the authoritative discourses in which students, Saraswati and myself were immersed at the beginning of the academic year. I will attempt to demonstrate the presence of authoritative discourse across different scales. Thus, my analysis will move from the macro level of the overall structure of the topic, to meso level considerations of lesson structure and, finally, to micro analysis of specific sequences of utterances and replies in selected incidents. The aim is to demonstrate how students and teachers are bound to and by discourses not of their making and how they are appropriated by these discourses to which they belong to recreate features of the discourses.

Structuring Authoritative Discourse: Explanation, Example, Exercise and Evaluation

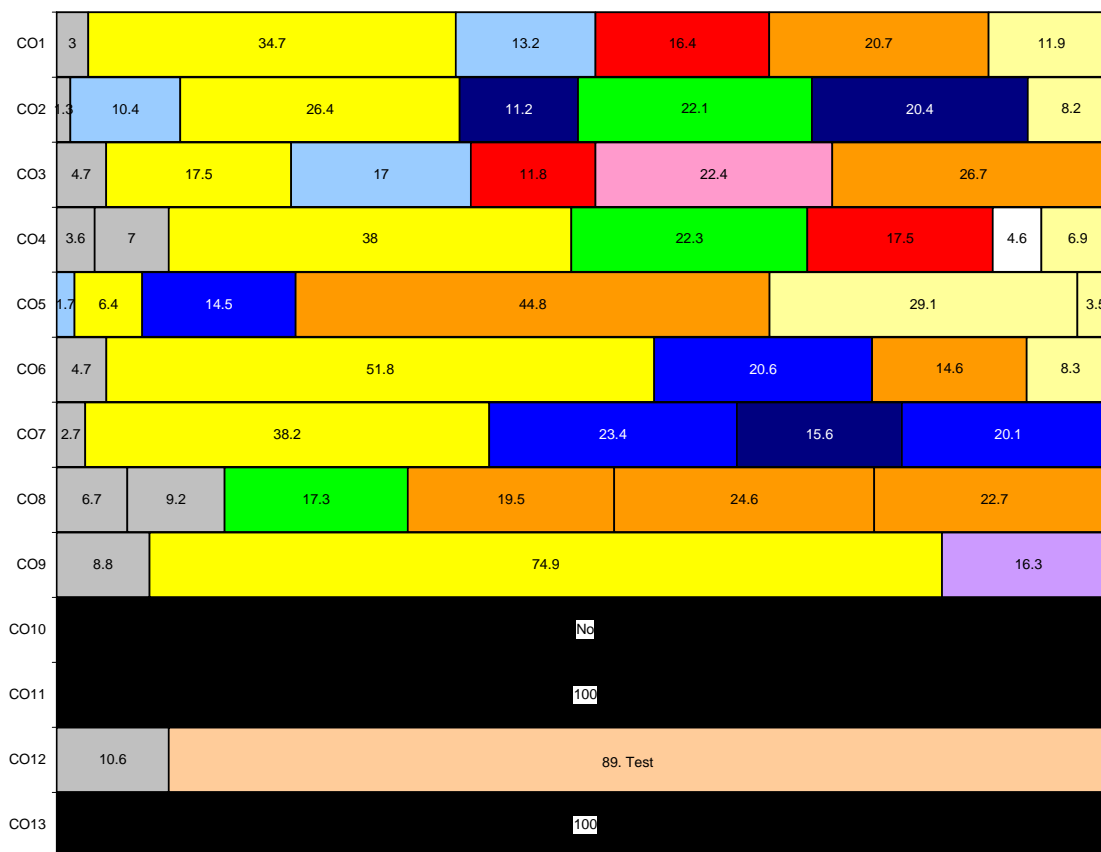
In the last chapter students' discourse model relating to mathematics teaching revealed that students perceived a generalized structure to their mathematics class activities. This sequence was described by Ivanna who stated on her questionnaire that,

“In my typical mathematics class the teacher would explain step by step and show us examples then let us do some problems and then correct and explain each one.” There are four events in this sequence – explanation followed by worked examples, an exercise and a final evaluation all of which are initiated and authorized by the teacher.

Over the first three weeks of the term as I observed students’ and their teacher’s engagement with the single mathematical topic of number bases, this sequence of explanation, example, exercise and evaluation was a recurring feature of lessons. There is also a sense of this rhythm in the overview of classroom observations in Table 5.1, Table 5.2 and Table 5.3. In Figure 7.1 below I have attempted to make this more conspicuous by illustrating and comparing the percentage of class time spent on these different activities. This provides an overview of the sequence of events within individual lessons as well as the overall sequence of events for the period I was on-site. The most obvious feature is the large percentage of time spent in correcting homework (bright yellow) at the beginning of almost every class. I have considered this to be an evaluative event since Saraswati was assessing the correctness and adequacy of students’ answers and students were also receiving evaluative feedback on their working and explanations. Paralleling this is the time spent, usually at the end of the class, assigning homework or working problems from an assigned exercise. Both teacher and student explanations as well as note calling and review I have considered to be explanations while teacher and student worked examples are considered examples. In addition, at the end of the topic there is a final exercise/evaluation activity (CO12) in the form of a period long assessment/test.⁵ This sequence of explanation, examples, exercise and evaluation is

⁵ I use assessment and evaluation fairly interchangeably. In the Trinidadian context there are no official or published ‘standards’ by which teachers evaluate students’ work as there is in North America.

Figure 7.1: Sequence of lesson activities during on-site period for Number Bases topic.



Numerical values represent percentage of total class time spent on activity.

Grey = Setup, Form Teacher duties.	
Pale Yellow = Assign homework /Correct example/Correcting exercise	[EVALUATION]
Bright Yellow = Correcting Homework.	[EVALUATION]
Red = Teacher worked example	[EXAMPLE]
Orange = Class working on examples from text/teacher individually.	[EXERCISE]
Pink = Students reading text	
Pale Blue = Review of previous work	[EXPLANATION]
Blue = Student led instruction	[EXPLANATION]
Dark Blue = Teacher led lesson/instruction	[EXPLANATION]
Green = Note calling/taking	[EXPLANATION]
Lilac (CO9): Teacher gives instructions about the test.	
Light Pink = Students working on test	[EVALUATION]
CO4 White: Teacher attempts to correct a student problem/question.	
Black = No class due to absenteeism, school activity and school evacuation respectively.	

observable at the macro level of the topic (number bases) illustrated in Figure 7.1. The overall topic structure shows a movement from explanation (blue/green) and example (red/orange) to exercise (pale yellow) and assessment (bright yellow/light pink) over the three weeks.

A similar structure is observable in the individual lessons/classes that make up the topic as illustrated below (Figure 7.2). I have used the coding described in the previous paragraph and have indented the categories so as to illustrate the sequence.

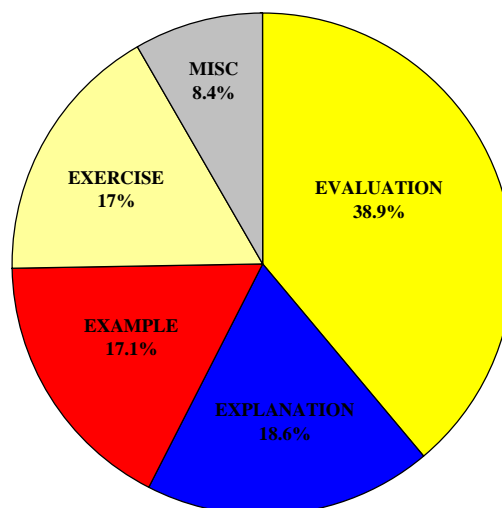
Figure 7.2: Sequence of lesson activities for topic number bases.

CO1:		Evaluation	CO5:		
	Explanation			Explanation	Evaluation
	Example			Example	
	Exercise			Exercise	
		Evaluation			
CO2:			CO6:		Evaluation
	Explanation			Explanation	
		Evaluation		Example	
	Explanation			Exercise	
	Exercise				
CO3:		Evaluation	CO7:		Evaluation
	Explanation			Example	
	Example			Explanation	
	Exercise			Example	
CO4:		Evaluation	CO8:		
	Explanation			Explanation	
	Example			Example	
	Exercise			Exercise	
			CO9:		Exercise/Evaluation
			CO12:		Evaluation

The percentage of time spent on each activity over the ten day period is summarized below in Figure 7.3. This shows that over the time that the topic number bases was taught, twice as much time was spent on evaluative type activities, mainly correcting

homework, as on any other activity. The pie-chart does not, however, illustrate the time that students would have spent completing homework exercises outside of class.

Figure 7.3: Percentage of classroom time engaged in lesson activities.



The structure/sequence is also apparent in the presentation of the topic in the textbook chapter as shown below.

Figure 7.4: Outline of textbook chapter

Number systems (1): The place value system and number bases.

Counting, Symbols for numbers, Tally system

Explanation/Commentary
 Example
 Exercise 1a

The place value system

Explanation
 Example
 Exercise 1b

Number bases

Explanation
 Examples
 Exercise 1c

Other bases of counting: seven, sixty, twenty four

Explanation
 Examples (5)
 Exercise 1d

Converting base ten numbers to other bases

Examples
 Explanation: Algorithm
 Example
 Exercise 1e

Converting from other bases to base ten

Example
 Explanation
 Example
 Exercise 1f

Summary

Though evaluation is not explicitly identified here, self-assessment was available to students in the form of answer keys located at the end of the textbook. This was a new addition to their mathematical discourse and many students expressed surprise at being given the answers. The paralleling of the lesson structure (Figure 7.2) with the textbook's structure (Figure 7.4) reinforces the discourse model of the students described above. It is authoritative in the sense that it does not dialogize its context. It does not enter into dialogue with its participants; they must either affirm it or reject it, and in the context of school it is affirmed through the authority of the teacher.

In several interviews Saraswati and I spoke about the authorities that underlie this discourse. The syllabus and the textbook were the two most (physically and temporally) accessible authors of the discourse for her. The choice of topic with which she begins the term is influenced by the congruence between these two authorities. Further, these authorities are backed by that of the government and the Ministry of Education. Such authority is difficult for a teacher to question or interrogate and is simply received and implemented though often not without some personal conflict. The text is likewise authored by individuals who are inaccessible (to the teacher) and its authority is bound to the authority of the SEMP syllabus and the associated list of approved textbooks which is also provided by the Ministry of Education. In addition, Saraswati is a part of a larger Discourse regarding an acceptable pattern of textbook usage that is a characteristic of the school community to which she belongs and which exerts a strong pressure to conform. The syllabus, the text and community expectations all act together to authorize and validate a discourse that is highly structured.

Saraswati does not recall being taught this topic as a student and is thus a bit uncertain regarding her mathematical content knowledge. Consequently she relies heavily on the authority of the textbook (and its authors) to inform both her content knowledge as well as the pattern of her lesson structures. However, it is the distant authorities that provided the ultimate justification for the method that she teaches as in the excerpt below (T.I.6) where we had been looking at an algebraic proof of one of the methods

Saraswati: I just believe that mathematicians many years ago, they proved it. 144

Saraswati: ...to show them that, the best explanation is to talk about mathematicians have proven it... 146

I: In years gone by...? 147

Saraswati: Well and still today, but you know it's a very intricate procedure which we rather not get into 148

The excerpt reveals the authoritative aspects of the discourse in which the authorities are unquestionable. Additionally her description of the proof as “a very intricate procedure” reveals a view of a mathematical past and task that is viewed as hierarchically higher than her own.

Saraswati: I never really looked at this so much in depth and actually...from what you just pointed out I find this makes a lot of sense you know? It's just like you know the whole thing about history kind of repeating itself, your teachers did things the same way and basically you think that's how it should be and the whole education system, the children that you dealing with are changing all the time. 77

In the excerpt above (T.I.3) Saraswati expresses her own sense of involvement in the reproduction of authoritative discourse. There is a sense of frustration and an awareness of her complicity in replicating the discourse practices of her teachers. Taken

together with the authority of the textbook, mathematicians, the syllabus, the government and the school community these help to explain how the authoritative discourse patterns observed in the classroom are created and are in fact re-created.

In the next section I will examine aspects of episodes that I have coded as Evaluation and Explanation for their contribution to the authoritative discourse in the classroom.

Evaluation

The majority of class time during the first three weeks was spent on evaluative activities. These activities included the correction of homework and a period/lesson long assessment that was intended as a review of the topic and did not count towards students' final mark. These evaluative activities are important elements of the authoritative discourse in the classroom. Below I examine the content of both types of evaluative activity and how they were interpreted by participants.

Homework

Almost every class began with the correction of exercises assigned on the previous day (Figure 7.1). The structure of this activity followed a simple Initiate, Response, Evaluate/Initiate (IRE/I) pattern in which Saraswati would read the question (I), the assigned student would answer (R) and Saraswati would provide evaluative feedback in the form of comments such as "good" or "very good" (E) while quickly moving on to the next student (I). This is illustrated in the first part of the excerpt below. Students were selected sequentially by the teacher so that everyone in the class had at least one opportunity over the three weeks to answer a question either verbally or by presenting their working on the blackboard.

CO4:

- Saraswati: Okay Exercise 1d so number 1, [reads question] “A baby is three weeks and four days old. What is its age in days? Nadine?” [I]
- Nadine: Well three weeks is twenty one days, and add four days, twenty five days. [R]
- Saraswati: Okay good everybody agrees? Okay number 2, Bridgette,... [E/I]

This type of interaction was typical of the majority of the time spent correcting homework. In addition to providing authoritative and evaluative feedback to the individual student, Saraswati attempted to incorporate class members’ perspectives by asking whether they agreed or not. In the excerpt below for example the class lets both Saraswati and the student know when an error has been made.

CO4:

- Saraswati: Okay, good, umm, Priscilla,
- Priscilla: Three days fifteen hours and forty minutes plus two days eight hours and forty minutes...five days fifteen hours and twenty minutes.
- Students: No [hands shoot up around room, teacher pauses]
- Saraswati: Okay...Gertrude..you agree with Priscilla’s answer? Let’s hear what you got.
- Gertrude: Miss I got six days, and twenty minutes.
- Saraswati: Okay good, You just want to tell us how you got that?
- ...
- Saraswati: Okay, very good.

Student errors made during the correction of homework were usually dealt with in the fashion illustrated above. Members of the class often were the first to indicate that the student’s response was inaccurate either by saying “no,” “it’s wrong” or through quiet whispering. Saraswati was careful not to give a negative verbal evaluation to the student by responding that her response was wrong and quickly moved the spotlight off the student onto another who would provide the correct answer and explanation. Positive

evaluation was provided by Saraswati to students only when they answered correctly while negative evaluation was provided by peers' comments. This evaluative statement provided the authoritative end to the dialogue and began a new one.

In addition to providing evaluative feedback, the correcting of homework also facilitated the initiation of students into the discourse of what constituted an acceptable solution/explanation. For example, on several occasions, after requesting that the student explain how she arrived at her answer Saraswati would proceed to model via her own utterances how she expected students to answer these questions. In the interactions that followed students' responses would follow very closely a similar pattern to Saraswati's.

The two excerpts below refer to students correcting homework by writing their working on the board at the front of the classroom.

CO6:

Saraswati: Now the reason I am asking them to write it on the board is cause I just want you to look at the working as well, not just the answer, so, look at number ten check to see if everything is correct, if it's similar to yours...

CO9:

Saraswati: So Jasmine you just want to explain what you did for number 11.

Jasmine: [rises slowly explains her working from her seat] 120 to the power of 3 is, you multiply one by the base, so you get one by the three, and then you plus three by plus two, and you get five, and you multiply five by the base again which is three, and you get fifteen, and you doh have to add it to the zero so you get fifteen.

Saraswati: Good, and you add it to the zero and you get fifteen. Okay and since the zero is the last number we end there. Elizabeth...

Again the purpose of correcting homework in these excerpts was to provide an opportunity for students to see and hear what correct responses look and sound like and to

engage in self-evaluation although Saraswati still provided the final authoritative evaluation of their work. The discourse that students are being encouraged to ‘follow’ is one in which answers alone are insufficient and reasoned explanations must be given. These explanations, however, look and sound a particular way. Initiation in and internalization of this discourse is important for students’ later success in terminal examinations which I discuss below.

Given that the correction of homework occupied the majority of the class time and that students in their questionnaire responses had stressed homework’s importance as being central to understanding mathematics, I probed this aspect of classroom life in the interviews. Two contrasting states are revealed in the excerpt below.

S.I.5a:

I:	So do you think too much time is spent in class correcting homework?	49
Aaliyah:	No...When you correct your homework is like practice, because is like actually doing the work, cause you going through it and...	50
Naobi:	Is like a repeated, a monotonous...	51
Naobi:	It’s... No, it has nothing to do with going over the questions, it’s homework and then miss teach, and then give homework and I want something different.	54
Ophelia:	You think class is based on homework?	55
Naobi:	I want something challenging...	56

In the excerpt above there is some disagreement among the students regarding the value of the time spent correcting homework in class. For Aaliyah and Ophelia correcting homework affords them the opportunity to practice and review mathematics respectively. These are both important elements of students’ (prior) discourse models regarding the learning of mathematics. For Naobi, though, the repetitive nature of the activity is “monotonous” and she perceives a general structure of the class that is

unsatisfying for her because it fails to elicit that which many students find enjoyable in mathematics – a sense of challenge. These sentiments are also reflected in other students' responses in the excerpt below (S.I.5b).

- I: ...Do you think too much time is spent correcting homework. 34
- Lillian: No. Well I think too much time is spent doing it on the board and explaining it, because if you explain it first then you understand it already but if someone doesn't understand it, then ask. 35
- Jasmine: Yes. Yes we is hardly get, miss is spend more time explaining the homework than doing the topic that we supposed to be... 118

Despite the importance for uncovering error and improving understanding several students interpret the practice of correcting homework in class as time consuming and reducing the amount of time that the teacher is able to spend in teaching topics. There is a sense of personal deprivation and ennui in their utterances as students struggle with this element of the discourse. Though they may wish to proceed differently and offer suggestions as to what can be done, they are unable to effectively challenge or change the pattern of the discourse. They are required to accept it in its entirety. It is, in this sense, an authoritative discourse.

Testing/Examination

The second element of evaluative activities was a review exercise/assessment/test at the end of the topic in the third week of the term. This again was part of the larger Discourse of the school community as several similar assessments took place in other subject disciplines during the same week. One of the main features of the discourse to which Saraswati was attempting to introduce students was one in which partial marks are awarded for working and explanations and not only for final answers. This is a common

practice in terminal examinations at the secondary level in mathematics. Saraswati thus sees herself as helping to prepare students to do well in mathematics in the future. The importance of showing one's working and being clear in one's reasoning are visible in the classroom excerpts from the previous section and is stated explicitly in this utterance taken from the class at the end of the first week (CO3):

Saraswati: Okay so you have to show working, compulsory, you get marks for working and then, wherever necessary you will write statements.

Here at the very start of these students' secondary mathematics career they are introduced to a powerful discourse regarding success in examinations at secondary level. It is a discourse that relies on the teacher's authority. It is also tied into students' view of the importance of paying attention to the teacher described in the previous chapter. This discourse is reinforced in the marking and post-test review where, as Saraswati explains, (T.I.6):

Saraswati: Well I invited them to come to the board and I just basically showed them exactly where I allotted the marks and that kinda thing cause a lot of them were surprised, cause although they got their expansion wrong they were surprised that they got two out of three instead of like wrong. 45

In her post-test review Saraswati showed students where they 'lost' marks and explained where and how marks were allotted. This was surprising for many students who perhaps had a perception of marks being awarded in mathematics on an all or nothing basis. This introduction to this aspect of secondary school mathematics discourse is meaningful to students like Naobi who seem to appreciate knowing exactly where marks are allotted and what is required of them.

S.I.7:

I: So what was different about the way you had to do the test slash review last week from

how you accustom doing tests? 41

Naobi: Well you just like, acknowledge your mistakes and you actually, when you first receive your paper and you see the mark you get, is like, how I lose like three marks or how I lose four marks, when you actually review the paper and you see... 42

This action seemed to demystify mathematical evaluation (though not necessarily mathematics itself) for the students by revealing an aspect of the discourse to which they had not previously been admitted. It is however authoritative in that the allocation of marks rests on the authority of the teacher and of external examining bodies which use this system of awarding partial credits. It is authoritative as well in that students themselves are not permitted to challenge the allocation of marks but must learn the discourse of how and where these marks are allocated. In this way it resembles and is perhaps linked to students' acknowledgement of the importance of clue words discussed in the previous chapter.

Other aspects of the discourse surrounding evaluations and testing that are authoritative are found in the instructions that Saraswati gave to students before the test. In her instructions to students prior to the exam Saraswati introduces them to the discourse practices that they will be adopting in this high school for examinations. Objections are dealt with by an authoritative reference to being in "secondary school now." These practices include not copying the questions, using their own working paper (as opposed to an answer booklet), writing the proper headings, showing all their working and writing in pens.

After the test Saraswati explains why she gave those instructions (T.I.6).

Saraswati: Well copying the question would have taken up time that they would have needed actually to do the question...Pen well because in Isabella all your exams should be

written in pen and basically you're kinda instilling a sort of what you call it ...well you know at the end of form five, CXC they require that you write in pen and that kind of thing, so basically if you start reiterating the point that all your exams should be written in pen by that time it should be a normal practice for them. 21

These practices are ones that students must become accustomed to if they are to do well at secondary examinations such as the Caribbean Examinations Council examinations (CXC). It is vital to their later success in school that they accept this discourse.

It is the seemingly trivial instruction that students are to write in pens as opposed to pencils, however, that evokes a strong objection from many in the class. In my final interview with students Naobi explains its importance for her and the relations she sees between the use of a pen and her performance.

S.I.7:

- Naobi: The pen kinda hinder me from doing properly cause when I doing my maths, normally I
accustom to doing it with pencil for every test... 44
- I: So you could erase? 45
- Naobi: Yeah, that hinder me a lot. 46

Though Bakhtin speaks about “special scripts” being used to set authoritative discourses apart, in this secondary mathematics class another element seems to be the need for special instruments. In addition to learning what their mistakes were, and where and how marks were awarded, important aspects of becoming successful secondary mathematics students, students are also learning that their mistakes are indelible, they will not be able to erase and present ‘neat’ and ‘tidy’ solutions as they were able to do in the past.

Working with the more permanent medium of ink thus seems to suggest that one must be more certain of one’s answer and approach before committing pen to paper. It suggests that there is less room for student error and experimentation and that one must know what

one wishes to write before one begins. This may act to create or reinforce conceptions of mathematics as having only one right way to solve problems and may work with students' prior discourse models regarding challenging and complicated problems. As Naobi attributes above, the inability to erase, a part of her prior discourse, affected her performance in the exercise. Again the authority behind this discourse which demands one instrument be used over another lies outside of the school though it operates through agents within the school. It is again not something that students or their teachers can oppose. They must simply accept and become accustomed to these elements of the discourse if they are to continue to progress.

Explanations and Examples

Its language is a special language. It can be profaned. It is akin to taboo, i.e. a name that must not be taken in vain...it demands, so to speak, not only quotation marks but a demarcation even more magisterial, a special script for instance... (Bakhtin, 1981, pp. 342-343)

Authoritative discourse cannot be represented – it is only transmitted...It is by its very nature capable of being double-voiced; it cannot enter into hybrid constructions. If completely deprived of its authority it becomes simply an object, a relic, a thing. It enters the artistic context as an alien body, there is no space around it to play in, no contradictory emotions- it is not surrounded by an agitated and cacophonous dialogic life, and the context around it dies, words dry up. (Bakhtin, 1981, p. 344)

After evaluation, explanation and examples occupied the majority of the remainder of classroom time. Saraswati's explanations often involved the use of examples to illustrate a mathematical idea or algorithm. After students had observed the examples Saraswati usually dictated a short note that outlined and summarized the method being used which students copied into their notebooks. The pattern of interaction was typically one in which Saraswati 'told' students what the results were and how

problems were to be done. Students were generally asked to provide answers to simple computational problems during the working of examples through the use of ‘cloze’ type questions. Cloze type questions, according to Pimm (1987), are based on a “fill-in-the-missing-word” task used in reading research. He writes, “Teacher questions in mathematics are frequently what might be called ‘clozed’, that is, where a one-word answer will suffice, and this is often all that is in fact, desired” (p. 53).

Below I relate several incidents that occurred during events coded as explanation or example and which were probed further in the interviews. There are several elements within these incidents that I consider to be authoritative. These elements include the induction of students into the use of “special mathematical scripts” or ways of inscribing mathematical thoughts and activities, the inaccessible and unchallengeable monologue of mathematical authorities and the transmission of a discourse which attempts to limit/silence heteroglossia. Though it is possible to organize this material by the themes listed previously I feel it is more important to present these in the contexts in which they originally occurred and to allow the reader to view the connections across the cases.

Case 1: “Why is two to the power of zero one?”

This example occurred during the first class that I observed (CO1). Prior to the excerpt below Saraswati had reviewed aspects of the base ten number system. Specifically, she questioned students on the number of symbols, the highest and lowest symbols and the expanded form of numbers in base ten. Using this as a point of common knowledge she then began to explain how the place value system for base two was constructed:

Saraswati: Okay, so now we’re going to try to write the place values for some of the other base systems, okay? Now if I were to use base 2 right, and I had to formulate the

place value system for base two, basically would follow the same place value system as base ten but instead of using the base number as ten since it's the base two number system, what number do you think I would use as the base?

Ss: Two

Saraswati: Two, good, and it will follow that when I use two I will start with 2 to the power of zero, 2 to the power of 1, 2 to the power of 2, good? So now I am going to erase this and put place value for base number 2 [Writing from Right to Left]

←-----

2^4 2^3 2^2 2^1 2^0 .

Students watching Teacher write on board.

Saraswati: So the first thing we would have on the right hand side would be two to the power of...zero, then two to the power of...one,

Ss: [repeating after teacher] Two to the power of zero... two to the power of three, two to the power of four.

Saraswati: Right, so the first thing that we started with would be?...

Ss: Two to the power of zero

Saraswati: Two to the power of zero would be...

Ss: Zero...One...One.

Saraswati: Remember anything to the power of zero we said was...

Ss: One

Saraswati: One, good. We start with ones, then 2 to the power of 1 would be...

Ss: Two

Saraswati: Two to the power of 2 would be

Ss: Four

...

Saraswati: So instead of having ones, tens, hundreds, thousands...we would have...[points to numbers on board]

Ss: [Repeat numbers] ones, two's,[one person – three's],four's, eight's, sixteen's.

Saraswati: ...and you go on right...?

In this dialogue, the teacher is the voice of mathematical authority despite her attempt at inclusivity in her language and pedagogy. Even though she begins by saying that the group is about to undertake an activity (we're going) the language points to herself as being the one who is doing (if I were, I had to, I would use). Saraswati then is the possessor of the knowledge and is the one doing. By using the collective pronoun "we" though, she seems to be attempting to give the students some degree of ownership of what is being done by (temporarily) including herself as a member of the class collective and seeking to draw students into the other mathematical group to which she belongs. However it is not really the 'we' that speaks, it is the 'I' of the teacher. In this way students do not come to own or construct the material that they study but rather inherit it in an already complete form.

Pimm (1987) explores this question of "Who is 'we'?" (p. 64) in mathematics classroom communication as he asks "who is the community to whom the teacher is appealing in order to provide the authority for the imposition of a practice which is about to be exemplified?" (p. 69). In the excerpt above "we" seems to refer to both the (present) community of the classroom as well as the (absent) community of mathematicians, mathematics educators, government and school officials and textbook writers. One of the consequences of using 'we' to delineate the magisterial script of mathematics that Pimm (1987) suggests is that it conveys the message that, "there are...*in-groups* in mathematics, where 'doing it right' has solely to do with conforming to the uniform practice of this elite group" (p. 70). This is an idea I return to below.

Additionally, Pimm (1987) suggests 'we' can also be used to conceal how a teacher *actually* performs the procedure for herself. This, he suggests, might help to account for "a common fear in mathematics of involving and exposing the self" (p. 70). However the authoritative 'we' provides no refuge or comfort and can accept no responsibility when one's mathematical self becomes exposed.

Student replies to clozed teacher questions in the excerpt are brief and largely rhetorical; they repeat what they see on the chalkboard or perform a relatively simple calculation. This again is an attempt to be inclusive and give a sense of participating in the process of formulating this system. However, theirs is an unequal contribution and, as Pimm (1987) notes, "it allows the teacher to remain in control of the discourse..." (p. 51).

Another aspect of the language of this excerpt is references to starting points, beginnings (I will start with,...The first thing...) and sequences (...then...). 'Writing' a base system then becomes an exercise in following a sequence of steps, a sequence of steps that if followed correctly, leads inexorably to a predetermined conclusion, a correct answer.

"Following" is also used in another sense in this excerpt, that of a stable relation between two entities, in this case the way the base ten system is written when ten is replaced by two. "It will follow" is a common mathematical idiom much like the familiar 'it is obvious...' that appears in many proofs. Here I think we are offered a glimpse of the influence of the larger mathematical Discourse. It *will* follow is a very strong statement of fact and has an air of inevitability. "It will follow" is used here to link the base ten number system with the base two number system. "It will follow" seems to be

functioning like the relation in a dialogic space – the place from which meaning emerges. “It will follow” here functions to make the parallelism between the two systems appear to be obvious and natural and distinct. What is linked is not the mathematical ideas underlying the number system, but rather the language of expression of those ideas, here presented in its special script, index form.

The procession of mathematical subjects sees Saraswati following the ideas she has encountered in her schooling and in the textbook. The students too are following. They attempt to follow their teacher’s explanation and the sequence of steps that asks them to follow a relation between the way in which a mathematical idea, whole number base systems, is expressed in a particular mathematical shorthand, that of indices. To truly believe that ‘it will follow’ becomes almost an act of faith. “It will follow” is a powerful authoritative (mathematical) script.

This dialogue between the teacher and the class on how to construct the base two number system is interrupted when Marian, a shy student in the front row, raises her hand to ask a question. Pointing to the chalkboard she asks,

Marian: Why is two to the zero one?

Saraswati: [To Marian] Cause that’s just a law...

Saraswati: [To class] Okay, so Marian is asking why is it one? There is this rule in mathematics any number to the power of zero is always one. Yes a million, a million to the power of zero is...

Ss: One.

Saraswati: One. Okay, so you could make a little note of that,

[There is a sudden burst of activity as students become active]

Saraswati: [calling note] “Any number to the power of zero is equal to...one”

[The teacher waits while they complete writing]

This short sequence illustrates the three themes identified above. In the first instance, two to the power of zero, or as students saw it, 2^0 , is a special mathematical script. On the surface then Marian is seeking to understand the relation between two written forms, 2^0 and 1. Writing the sequence of powers of two is not problematic for her, but there is a discrepancy between the expression 2^0 and its stated equivalence with the value one. Saraswati's authoritative response that, "[i]t's *just* a law" does not dismiss Marian's question as being unimportant, since Saraswati goes on to suggest to the class that they can make a note of it. However, it does dismiss the mathematical underpinning of the formal mathematical expression 2^0 as well as Marian's conceptual confusion. Further, by continuing on to state that there is "this rule in mathematics" she locates the authority underpinning her statement as belonging to mathematics itself and not herself. In this way she places herself at the intersection between the classroom 'we' and the authoritative 'we' of the mathematical community and directs students in "conforming to the uniform practice of this elite group" (Pimm, 1987, p. 70) In this way neither her authoritative statement nor the mathematical script upon whose authority it relies can be effectively challenged.

Finally, although Saraswati's first statement that "it's just a law" seems to put the 'fact' in a subordinate position to what they are currently learning (how to construct base two) her later suggestion/instruction that they could "make a note of that" elevates it to the privileged position of something to be committed to the permanent record of their notebook, something potentially meaningful and important. The students' physical response to this utterance is itself informative; now that they have been given a directive which utilizes the key phrase "make a little note," students become active and more

engaged. There is a sense of release and finality as students snap shut their pens following the note taking. By committing the fact to the page as something to be learnt and remembered, disembodied from its context in this lesson the question is effectively laid to rest. It has been added to the mathematical arsenal of the students. It has been transmitted and its transmission has attempted to eliminate any possibility for further dialogization with its context and the heteroglossic nature of the social situation.

The conception that mathematics is a set of rules/procedures to be followed is one that I encountered frequently in the literature prior to conducting this study and one that I myself have held as both a teacher and a student. Thus, this particular dialogue immediately stood out for me as a potential example of how such a conception could arise or be reinforced. In the excerpts below several students speak about this incident:

S.I.1:

Marian:	I am not sure why you put zero...	24
I:	And what did Mrs. Ousman say about it?	25
Marian:	She said it was a law in maths. That you just put zero when you multiply it.	26
I:	So what do you think about that?	70
Allison:	I...really doh know who invent that and I doh know why.	71

S.I.3:

Katija:	All she said was that 2 to the power of, there's a rule that any number to the power of zero is one.	137
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These excerpts demonstrate the way in which students' utterances on this issue have been appropriated by the authoritative word of their teacher. Marian and Katija are typical of students who state that "it's a law" or rule reproducing Saraswati's own utterance.

However these utterances also suggest that for Marian and Allison this law is viewed as simply a "thing" or a "relic" that they have received and must accept. There is some

dissatisfaction however in not understanding why this rule exists and who “invented” it which is reminiscent of Lillian’s comments in the last chapter (p. 98) about being able to do mathematics but not being able to understand how one is doing it. I will look at this dissatisfaction in more detail in the next chapter on internally persuasive discourses.

In following up this issue with Saraswati it became apparent that she too saw herself as an inheritor, a “distant descendent” and recipient of an authoritative mathematical discourse as she tries to remember if this was something that she had learnt.

T.I.2:

I:	...Marian asked why 2 to the power of 0 equal 1. Do you remember what you said about 2 to the power of zero?	35
Saraswati:	I don't know, I think I said anything to the power of zero is one.	36
Saraswati:	Something about some law of indices?	38
I:	Why did you say that?	39
Saraswati:	Because I was doing laws of indices with form fours so I remembered it...I mean questions like that I can't answer too...well, actually maybe I could you know? I think I did that already. I just didn't remember it at the time...	40

T.I.3:

Saraswati: Nobody really told me that they don't understand that 2 to the power of 0 is 1... 90

Operating from this position as both inheritor and representative she acts to transmit the discourse regarding the authoritative nature of mathematics and mathematics teaching to her students through her language and her actions. Her comment that she has not heard from the students that they were having problems understanding the concept illustrates how the authoritative word acts to limit heteroglossic feedback in the classroom.

Students who have difficulty understanding, according to the discourse models posited in the last chapter, have the responsibility of bringing this to their teacher's attention.

However, Marian's initial question has been authoritatively silenced by the response "That's just a law" and consequently students, though still uncertain, must come to accept this as an inexplicable rule simply to be followed. There is nothing further to be gained by engaging the authority.

Case 2: What's the relation?

This second example follows the dialogues emerging from and associated with Saraswati's explanation and example of how to convert numbers in base ten to another given base. It occurred several days after the incident described in the previous case.

C04:

Saraswati: Okay today what we're moving on to is converting base ten numbers to numbers in other bases. Alright, so the first thing I'm going to do is give a note then I'll do an example and then I'll have you try some

Saraswati: So, the heading is...Converting numbers in base ten.....[Ss opening books, uncovering pens] to other bases.....So, when converting, when converting...a number,

S?: What's the heading again miss?

Saraswati: Converting a number in base ten to other bases...

Saraswati: Okay, so when converting a number, when converting a number in base ten... to a, to a number,...in another base,...Step 1, Step 1...Divide, the, given number,..... in base ten...by the base,... by the base,... to be converted to...

Aaliyah: Miss you could repeat that,

Saraswati: Okay, so divide the given number...which would be in base ten, by the base to be converted to. Good, so if you have...yes Michelle,

[Inaudible: S asks teacher something]

Saraswati: So divide the given number, and that would be in base ten by the base to be converted to.

Saraswati: Step 2, repeat...division until,.....the quotient, is,...zero,...writing the remainders,

.....so repeat division until the quotient is zero...writing the remainders, down for each division,..... even if, it is zero, even if it is zero, so I will repeat it again, repeat division until the quotient is zero, writing the remainders until the quotient is zero writing the remainders down for each division even if it is zero. And the last step, ...to write the new number, Step 3, to write the new number.....in its, new base...in its, new base,.....read the remainders,.....and write them,.....[erasing board] from the bottom to the top..... And in brackets I just want you to write, write the base, write the base number,...at the bottom right hand corner.

This episode is typical of the feature of lessons coded as note calling. There is a discernible structure to the sequence of utterances. Saraswati's first utterance is to outline the sequence of events in the class as described above – explanation, example and exercise. First she will tell them how to perform a procedure, next she will demonstrate how the algorithm works and then they will attempt one on their own. The note itself has a simple pattern – a heading summarizing what the procedure does and a series of steps. The language is one of transference – “giving” a note and sequential cues – “step 1”, “until” and “the last step.” This sequence is taken almost verbatim from the textbook (p. 5). There is one noteworthy change, namely the emphasis that Saraswati places on remembering to write the new base as a subscript which is probably linked to her past experience with student errors and in marking examinations. In this excerpt we again see mathematics presented as a finished ‘thing’ in the form of an algorithm.

In the next part of the class Saraswati illustrates the algorithm with a concrete example:

On blackboard e.g. Convert 123 to base five.'

Saraswati: Okay so we have this example, umm, Convert the number one hundred and twenty three and this is in base ten, to a number in base five...Now this method of converting is

repeated division. So the first thing we do is we divide 123 by the base we are going to convert it to which is [pointing at five on board]

Ss: Five

[Drawing vertical line, horizontal as for repeated division]

Saraswati: So we start dividing, 5 into 123, how would we go about dividing 5 into 123? Say five into...

Ss: Twelve

Saraswati: Twelve, will give you...

Ss: two

Saraswati: two remainder...

Ss: two

Saraswati: two, put it up here and the next step, five into twenty three will give us...

Ss: Four, remainder three.

Saraswati: Four with remainder three, now remember step 2 tells us that we have to write the remainder, so [writes on board 24 R 3] remainder three.

Saraswati: Now in this here, what is the quotient? From primary school?

S?: The answer in the division.

Saraswati: Okay the answer in the division. Now, is this answer here zero? What we looking at is this here [cups under 24] Is this zero?

Class: No miss.

Saraswati: No it's not so we continue, we repeat the division, so since it's base five we keep dividing by 5, good, 5 into 24...

Ss: Four

Saraswati: Four, and the remainder is

Ss: Four

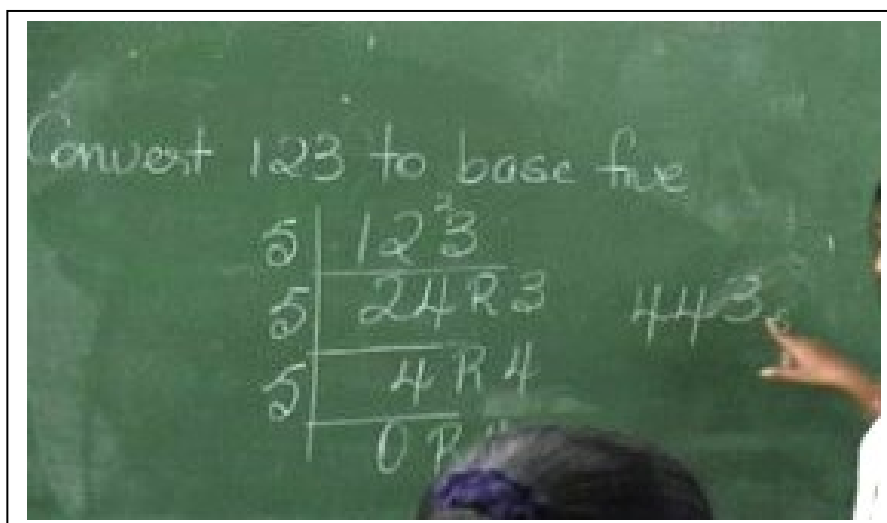
Saraswati: Four [writes 4R4 on board] And then is this zero as yet? So? So? ...so you continue, you divide by 5. So 5 into 4 will give us...

Class: Zero.

- Saraswati: Zero
- Class: remainder 4
- Saraswati: Remainder 4. So is the quotient zero in this case?
- Class: Yes.
- Saraswati: Yes. We have our remainders 3, 4 and 4...so that's step 2. Now Step 3 is to write all the remainders from the bottom go up, write it down and then put a little five next to the number. So if we had to write this number down from bottom go up what number would we get?
- Class: four, four, three,
- Saraswati: four, four, three, and then since the base we converted it to was 5 we write a small 5 at the bottom. So this number 123 in base 10 is really 443 to base 5. Right and just to make sure that it's correct you just look at the numbers to see that they're not five or more. Right so this is possible because all the numbers are less than...
- Ss: five.
- Saraswati: good, right so you just want to take down this example?

[Ss copying example from board.]

Figure 7.5: Example presented to illustrate method of repeated division.



This excerpt illustrates the general format that teacher demonstrations or examples followed. The teacher as the mathematical authority demonstrated step by step the previously described algorithm. Students were asked to provide the answers to simple computational problems which were largely rhetorical (clozed questions). This example also illustrates the themes of the transmission of a monological discourse which attempts to limit heteroglossia and requires the adoption of special (mathematical) scripts, for example, through the use of 'we'. The episode continues below with an interruption of the smooth and unproblematic transmission of the discourse by Katija:

Katija: Miss I don't understand the relation between the one twenty three and the four, four, three?

Saraswati: Well basically it's just this number. Remember once we don't have a number at the bottom right hand corner [pointing to 123] they're base 10, basically what we're doing is changing that base ten number to another base. So you're converting that base ten number to another base, so you're converting from base ten to another base. So this here, 443 with the 5 [pointing to board] is really this number [pointing to 123] in base five.

Katija: Oh...

Saraswati: Alright?

Xumei: I think she is asking why are you writing it four, four three...

Saraswati: Is that what you mean?

Katija: Ah, No, not really...

Saraswati: She just wanted to know the relationship between these two numbers right? This number is really this number in base 5 so you're converting it.

[Bell for end of class goes.]

[Katija does a gesture of uncertainty with her hand]

Saraswati: Okay we'll go over it again tomorrow,

After Saraswati's explanation and example and attempting one herself, Katija, following the model of learning and doing mathematics described in the previous chapter, brings her difficulty understanding to the attention of the teacher. In what sense can two different numbers made up of different digits be equal seems to be the question that results from Katija's inner dialogue. In this dialogue mathematical meaning remains elusive. Saraswati attempts to clarify by explaining that one two three (123) is "really" four four three (443) in base five. However, by beginning her explanation with "it's just" Saraswati seems to be saying that what is to be understood is a simple matter. Additionally, it is also the same phrase that she used to respond to Marian's question regarding two to the zero in the first case and which functions to convey her own as well as mathematics' authority. "Basically" introduces the logic of the explanation. "We're changing" and "you're converting" seem to be used interchangeably in this excerpt as Saraswati weaves herself in and out of the class collective. These also describe the action of the procedure. The meaning of these actions, because they are not explained further, remains elusive and mysterious and, consequently, "changing" and "converting" seem to be magical processes, a transubstantiation of sorts, once the ritual/algorithm is followed correctly. This number is "really" this number, however, seeks not to make the process by which the transformation is effected transparent but rather acts as a seal of authenticity, a final pronouncement on the matter by the mathematical authority invested in the teacher. Thus for students, believing that one number is "really" the other becomes almost an article of faith. I continued to follow this incident with Katija and Marian in the interviews (S.I.3):

Katija: I asked her what was the relation between this number (123) and that number (443).

I:	And were you happy with the answer that she gave you...?	4
Katija:	Well...yes I was kinda happy with it, but I just not clear...	5
Katija:	I don't understand how this number could be a next number in a different base.	7
Katija:	I understand her explanation, but I still doh understand why is a different number in different bases?	9
Katija:	... I don't know how to explain it, it's just...like she will tell me stuff and I will understand what she trying to say but I still won't understand.	13
I:	Okay you say you will understand what she is trying to say, meaning you will understand the words?	14
Katija:	Yes [nods emphatically]	15
I:	But you wouldn't understand...?	16
Katija:	The...relation...	17
I:	The relation between...	19
Katija:	The relation between the two different numbers.	20
Marian:	Basically what she trying to say is we know like what she is saying	26
Katija:	Like I did an example right, I did the one we had for homework and I got it out right, but I just doh understand, I know it have to be two different numbers in two different bases but I don't know why it has to be two different numbers!	27

In the excerpt above Katija continues to describe her struggle with the authoritative explanation provided by her teacher. Although she is able to decode what her teacher is saying and follow the steps correctly, she is unable to perceive the relation between the actions that she is asked to perform (and easily performs correctly) and the objects that she works with – namely numbers. However, the fact that the students are able to correctly perform the algorithm without understanding what is being done is an example of the way in which authoritative mathematical discourse appropriates students' activities for its perpetuation. Students are not free to reject it but must either continue to

struggle or simply accept the explanation that “it’s just this number, really.” The algorithm for converting numbers from base ten to another is simply a tool, an object to be used towards a specified end or, as Bakhtin describes it, a “relic.” Though the students are able to follow the steps in the procedure without difficulty and understand what their teacher has said (the words) the connection between these words and the images and the ideas that they are meant to represent remains elusive. Word, image and idea are not in dialogue. They seem to exist as separate entities. There is a discernible and growing level of frustration in Katija’s remarks over the course of the interview as she tries to make sense of *why* the numbers “*have to be different.*” Again, these comments resonate with others that I encountered and elaborated on before, particularly Lillian’s and Marian’s struggles with authoritative discourse. Authoritative discourse, it seems, is deeply unfulfilling and these students seem to be asking for a little more.

Two student errors: Writing remainders backwards & remainder zero

During their class work students made two different but related errors in working with the authoritative algorithm. They frequently forgot the final instruction to write the remainders “backwards” and also forgot to write the remainder when it was zero. As Saraswati moved around checking on students’ work as they practiced the method, she observed these two errors which prompted her to address the class about these issues formally:

CO5:

Saraswati: [Moves to front of class] One thing I need to point out, now a lot of you all are not putting your remainder zeroes now remember like in normal base ten if you have a number like one hundred and eighty you need to put that zero at the end to show place value. If you had left out that zero from the one eighty you’d end up with...eighteen. So

you change the value of the one from a hundred to tens. Good, likewise in other bases you need to put your zeroes to show your place value. Alright so whenever you dividing and you get a remainder of zero, write down the zero so that when you write all the remainders from the bottom going up you would incorporate that zero in it, okay?

Here by drawing on their previous experience and knowledge of zero's importance in the base ten place value system, Saraswati attempts to create a link that justifies including zero as a remainder. From students' previous work with division, zero was not considered a 'remainder' since division stopped when one got a remainder of zero. Zero has been largely invisible and inconsequential especially as a remainder. Additionally, Saraswati uses the utterance to remind students to write the remainders from the bottom up. By moving to the front of the classroom and highlighting these two errors in her utterance which interrupts the work in progress Saraswati foregrounds these as issues of importance, things worth remembering. This movement fits in with students' prior model of good teaching and learning and they pay attention. It is thus not surprising that in my interview with the students following this class that they recalled and discussed it.

Several students continued to express confusion about both the process of writing the remainders backwards (in reverse order) and the use of remainders at all. It was not a normal practice for them to read upwards or from the bottom to the top as the algorithm and its representation tell them to do. There is the suggestion that another mysterious transformation has taken place. The second area of confusion concerned the use of the remainders in creating the new number. Students' language suggested that remainders were seen as inconsequential. In previous work (calculation) by students, remainders have occupied a subordinate position to the quotient in the division algorithm. Indeed, it is not uncommon to hear teachers and students refer to them as that which is 'left-over'

after the division is carried out. These concerns and questions, though, seem to be rendered mute by the appeal to the authoritative word first uttered by Saraswati in the previous class that “it’s a law.” This authoritative word provides some comfort and relief in that students no longer have to struggle with the discord that they feel, but can, instead, rely on an authority in which they are able to place an unquestionable faith to assume the responsibility for justifying the veracity and integrity of the actions that they are asked to perform. The authority of the algorithm demands fidelity from students. Again the mathematical entity under consideration is simply a thing to be recalled. Further, the authority underlying the algorithm excludes the possibility of looking at and engaging the process in any other way. As Bakhtin suggests, authoritative discourse causes words to dry up. And where there are no words there is little possibility of imagining how it could be otherwise.

Both reading backwards (upwards) and writing remainders are not considered ‘natural’ by some students. This ‘unnaturalness’, however, is not something that one has control over but rather one must become “accustomed” to it. As students continue to practice questions they perhaps become more accustomed until it comes to seem natural that when one is converting between bases using this method that one must read from the bottom upwards and one must include zero remainders. Again, one does not question the authority of the discourse or attempt any modification. Rather the effort is spent on becoming accustomed to being asked to simply follow instructions based on the authoritative word of one’s instructor and one’s texts.

Authoritative discourse and Saraswati

Over the course of several interviews I discussed with Saraswati some of the

incidents described above:

T.I.3:

- I: What do you think Katija was asking about?... 35
- Saraswati: I don't know, she was asking the relationship between the number 123 and 443 to base 5. I don't know what she meant by relationship. 36
- Saraswati: ...she can't see that, you know, personally I could understand where she comes from, because personally I don't know how they could be two separate numbers as well, but at the same time basically, from what I explain, it's just, I mean, that's the thing as much as I understand that's what I explain. Right, like I see the 443 to base 5 as just that number written in another base. 63

T.I.4:

- I: Yesterday's class was mostly a practice class,...what were you checking for when you were moving around and looking at students' books? 3
- Saraswati: Basically I wanted to see if they understood, if they were making errors what kind of errors they were making and I noticed that there was one common error with most people and that was they weren't putting the remainder when it was zero. And I think that's a problem on my part... 4
- Saraswati: Cause although I had given them the note and I specifically stated even when the remainders are zero still put it, I didn't show an example where there are remainders with zero and I didn't fully explain why you should do that, yes it was an error on my part.6
- I: Some of them have the problem of remembering to write it...this way 31
- Saraswati: Actually this morning coming down in the car I was asking myself that, why do you read from the bottom go up?... But then I reached to school just as the bell rang and I didn't have chance to ask anybody. 32

These utterances reveal that Saraswati too is a recipient of an authoritative discourse. In the first excerpt, for example, she suggests that she too is confused as to how the two numbers could be equal. Her understanding of this topic, informed by her

experiences, the syllabus and the textbook, is inadequate to meet the needs and questions of students like Katija. Though the acknowledged authority in the classroom, outside of the class she positions herself similarly to that of the students, as another distant descendent and recipient of an authoritative mathematical discourse, one which she is ill-equipped to interrogate and one to which, perhaps, she has simply become accustomed. In the second excerpt Saraswati attributes students' errors regarding writing remainders to an inadequacy or deficit in her teaching. She suggests that, despite being told explicitly about these scenarios, they made these errors because she had not shown them an example with zero remainders which they could follow. The deficiency which she attributes to her pedagogy is one in which it is *her* failure to provide students with an exhaustive canon of examples that leaves the room for student error to occur. In addition, as her final utterance indicates, she too is searching for an authority to provide a justification or explanation for the unnaturalness of reading and writing from the bottom go up.

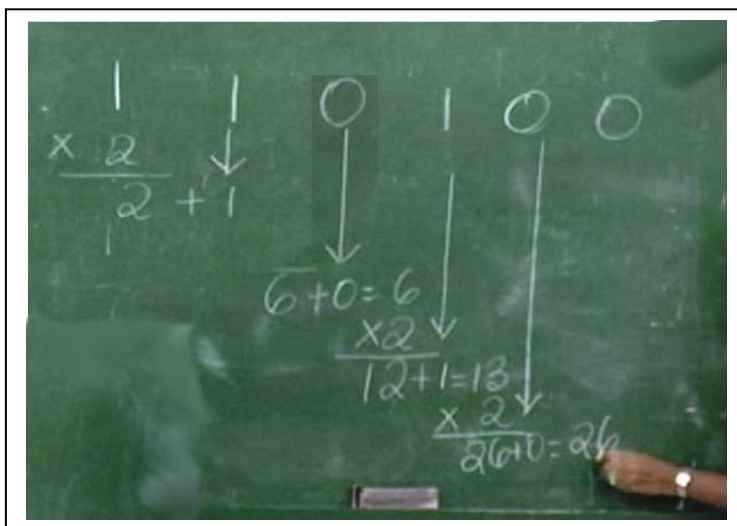
The discourse to which Saraswati belongs, for the discourse does not belong to Saraswati, is one in which her authority and identity as a teacher are wedded. Because of the hierarchical nature of authoritative discourse, whose authority lies in the past, it cannot be challenged in the present. For Saraswati then, as the representative of and conduit for the authority of mathematical discourse, the responsibility for students' failure to properly internalize and reproduce the discourse must lie in her own actions rather than in the structure, content, organization or practices of the discourse itself. In this way both the authority and the discourse itself are preserved and what yields to the authoritative discourse is one's sense of self.

Case 3: The last digit

In this third and final case many of the features that have previously been described as authoritative are present. I include it both for completeness as well as further illustration and evidence of the three themes listed at the outset, namely induction into the use of special mathematical scripts, the inaccessibility of mathematical authorities and the transmission of discourse that limits heteroglossia. I view the episode more as a recursive elaboration of the themes already explored rather than a redundant exposition.

In this case Saraswati explained by way of an example a (the) method for converting numbers in other bases back to base ten. Her explanation had been preceded by Naobi's demonstration of the method for the class. Both of their illustrations had included not only how to perform the algorithm but the actual form that the procedure should take in students' work, its special script as shown in Figure 7.6. The excerpt that follows picks up at the end of the explanation.

Figure 7.6: Example presented to illustrate method of repeated multiplication.



CO7:

Saraswati: and then you have one more number so I bring it down [draws bent arrow], plus you will have enough space, and you add zero to get 52 and that will be to base ten.

Allison: Miss but you doh have to multiply...?[pointing to last digit]

Naobi: You doh have to multiply the last digit. [states it as a fact]

Saraswati: No you don't, once you use the last digit here, the answer that you get finally when you add you don't multiply it.

In the classroom example, later note taking and the textbook, the material is presented as a series of steps to be followed with corresponding starting, ending and sequencing cues. Allison's question however, is an attempt to interrupt the official discourse as she seeks to understand, to make meaning, to have dialogue with the material as it is presented. It is quickly silenced by both Naobi, who had previously presented the material to the class and is thus seen at this time as an authority, and by Saraswati, whose authoritative words and positioning in the discourse act to terminate further discussion.

Allison's question though, like that of Marian and Katija in the previous cases, provides a point from which the authority of the discourse being transmitted is potentially vulnerable. This vulnerability, however, cannot be officially acknowledged by a discourse that is authoritative, but instead must be "denied all privilege." In the excerpt below (CO8) a student had just completed presenting an answer to a problem using the previously illustrated method on the chalkboard. Saraswati begins by echoing and re-voicing the student's mathematical argument.

Saraswati: Okay so that's it, you converting it to base ten, so since the base is seven you multiply by 7 to get 35 plus and you bring down the four which is the second number, you'll get 39, so that sum there, you multiply it by 7, right you get 273 and then the last number is 6, so

you bring it down and add, at the end you don't continue multiplying because that's the last number and you have nothing else to add at the end.

Saraswati: So at the final stage, the last addition, you stop...because [uncertain/hesitation] ... there are no numbers again.

Naobi: Miss you could only continue if you know there is a further digit for you to add to it, so...stop there. [folds arms]

Saraswati: Right.

Aaliyah: And plus if you multiply again you'll get the wrong answer.

The question raised by Allison previously as to why the algorithm stops where it does is addressed by Saraswati in the same manner as before – with an authoritative and declarative statement. To this is joined other students' voices which add to the authoritative chorus and extend the reach of the discourse into the peer network of the classroom. The idea that the procedure comes to an end because there are no further numbers is reinforced several times by Saraswati (in this class) and once each by Naobi and Aaliyah. Aaliyah's utterance that to multiply again would result in "the wrong answer" reveals that which is "taboo" in the discourse as well as that which is "sacred." Failure to follow the prescribed instructions places one outside of the community of certainty, the "elite *in-group*" in which authority is invested. All of these utterances though act to bury the underlying content of Allison's (and Marian's and Katija's) real concern – (mathematical) understanding.

Doing without understanding

For members of the classroom community the repeated immersion in and reinforcement of the authoritative discourse of mathematics class serves to confine their thoughts and direct their utterances and they begin to depend on the authority of mathematical rules as a justification for action (and inaction). In the excerpt below for

example Lillian and Michelle both express the fact that they don't understand the method but are able to do it because of a trust in a mathematical authority:

S.I.5b:

- I: Lillian, you said that you don't understand the rules, on your questionnaire and in the last interview you find the rules, "you just do it and you don't know how." Do you find that it's still like that now? 1
- Lillian: Yeah, like how Miss and how Naobi explained it with miss at the same time, I really didn't understand it, but I still did it. 2
- I: Could you explain to me what you mean by doing it? 7
- Lillian: Yeah...first you have to multiply, then add, then multiply again, I don't understand why? 12
- I: But you were able to do it? 13
- Lillian: Yeah [matter of factly] because that's what they say to do. 14
- I: [to Michelle] what about you? What do you think? 15
- Michelle: umm, well..., I dunno, I dunno why you have to multiply then add, then multiply and add again, but if is a rule or something I okay with it. 16
- Michelle: ...umm, cause it's a rule and we have to follow the rule in mathematics. 18

There are some interesting deictic elements in this excerpt. Lillian's use of 'they' points away from herself to external authorities, specifically Naobi and Saraswati, but it could also be referring to other authorities such as the textbook. 'They' is thus specific to those who have actually made utterances in the classroom but also serves to mask all of those whose utterances have contributed to the overall discourse. Unlike Saraswati's 'we' in the classroom, Lillian's 'they' excludes herself. 'They' are the authorities to which one appeals for understanding. In her statement Lillian then does not speak her own words but re-voices the word of the authorities in this discourse. Michelle too re-voices other's speech by prefacing her utterances with the authority implied by "Miss

said.” Having no authority for themselves and their own discourse they must rely on the authority invoked by using others’ words. Their own words have ‘dried up’.

Michelle’s comment that “if is a rule or something I okay with it” seems to suggest a positioning of the self in a subordinate position to that to which the ‘it’ refers, namely the authority that mathematical rules possess. It is an unquestionable and unchallengeable position of mathematical authority that is being created. Her second statement, that “it’s a rule and we have to follow the rule in mathematics” echoes Saraswati’s earlier response in the first case to Marian that, “it’s a law”. These two utterances together suggest an “allegiance” to the authoritative word that finds no justification apart from the authority that the word possesses. They are professions of faith.

Having no authority of their own, these students are forced to acknowledge and rely on the authority of the discourse to which they are bound. From this position their task becomes one of ‘*doing*’ (mathematics) without understanding and ‘*doing without* (mathematical) *understanding*’.

The whole thing just ends

Finally, consider Saraswati’s interpretation of her own utterance (T.I.5):

I: So when, after Naobi demonstrated, and you demonstrated, Allison and a few others were concerned about, multiplying by, after you add the last digit, multiplying by 2 or by the base again. I was wondering about that... 22

Saraswati: yeah, umm, my reasoning was, and obviously I am sure it’s not the correct reason, I told them that since you have no other numbers to add at the end you just stop, it was the last number you were working with and once you are finished working with that number the whole thing just ends. 23

Saraswati's previously expressed uncertainty regarding her familiarity with this topic as well as her position as the mathematical authority in the classroom places her in a position of conflict. As such, she is unsure of her reasoning and it seems that her utterance was not meant to convince but to offer a plausible fiction. She too is without the authority that the discourse itself possesses and derives her own as a representative of that discourse. Her statements though that "You just stop" and "the whole thing just ends" are definitive and declarative statements with a strong monologic tendency towards acceptance. They serve to effectively silence any criticism or objection. Saraswati too must do without understanding.

Summary

In this chapter I have examined elements of classroom dialogues that I consider to represent aspects of authoritative discourse in a mathematics classroom. These elements include a discernible structure and sequence to lessons within the topic which mirrors that of the textbook, the use of cloze type questions and teacher attempts at linguistic inclusiveness. In addition to authoritative structures there are authoritative words, practices and scripts. The immersion and interaction of both students and their teacher with these authoritative discourses leaves them both in a penurious state. There are points however at which authoritative discourse is vulnerable and it is to these that I turn to in the next chapter.

CHAPTER 8

INTERNALLY PERSUASIVE DISCOURSES

When someone else's ideological discourse is internally persuasive for us and acknowledged by us, entirely different possibilities open up. Such discourse is of significance in the evolution of an individual consciousness: consciousness awakens to independent ideological life precisely in a world of alien discourses surrounding it, and from which it cannot initially separate itself...

Internally persuasive discourse...is...tightly interwoven with "one's own word"...the internally persuasive word is half-ours and half-someone else's. (Bakhtin, 1981, p. 345)

In this chapter I wish to draw attention to some elements of the internally persuasive discourses that revealed themselves despite the overwhelmingly authoritative nature of elements of the classroom discourse discussed in the previous chapter. I organize the material according to whom the discourse was internally persuasive and thus I move from students, to the teacher and finally to myself as researcher. In each case though, others' words interweave with and implicate one's own words in the dialogic struggle to make meaning and come to understanding. My aim in this chapter is to illuminate and amplify the ways in which internally persuasive discourses reveal themselves in those moments and movements whereby they resist and thus makes one aware of the sharp, rigid, uncontested and unitary boundaries that authoritative discourse seeks to impose.

Students

Student Questions

The authoritative word's attempt to limit (or silence) heteroglossia and impose its monologism is continuously subverted by the internally persuasive utterance. In educational settings Britzman (1991) explains, "internally persuasive discourse

provisions engagement with what we know and the struggle to extend, discard or keep it: it is characterized by those surprising questions – raised by the students and the teacher – that move from exhausted predestinations to the unanticipated” (p. 21). Despite the potentially overwhelming elements of authoritative discourse observed during classroom episodes and discussed in the last chapter, there were moments in which the continuity and authority of the discourse were challenged.

Chief among these were students’ classroom questions as they struggled to make meaning from the mathematical material and pedagogy that they were receiving. These “unanticipated questions” interrupted the smooth transmission of the authoritative mathematical discourse in which they were immersed. The questions below from different lessons were all directed towards the teacher following her authoritative explanation:

- CO1 Marian: [pointing at chalkboard] Why is two to the zero one?
- CO4 Katija: Miss I don’t understand the relation between the one twenty three and the four four three.
- CO2 Katija: You could have base one?
- CO2 Nadine: Could you have a base number that has two digits in it?
- CO7 Ophelia: Will it really take up that much space in your notebook?

The first two examples, (which have been discussed in more detail in the previous chapter) deal with students’ conceptual difficulties in understanding new mathematical ideas and their representation. However, the next two questions (Katija, CO2 and Nadine, CO2) are concerned with the existential nature of the mathematical objects that they are studying. This concern is revealed in their language. “Could you have base one?” “Could we have two digit bases (greater than ten)?” Their utterances reveal their struggle

to extend the bounds of the usefulness of the mathematical idea by examining their own (concrete) conceptions of extrema. Nadine begins to push against the (seemingly) arbitrary boundary of ten as an upper limit for bases and the difficulties one might encounter in representing such a number. Katija works on another potential discontinuity – what is the smallest (positive integer) base? Ophelia struggles with the form of representation, the script, of the method of repeated multiplication which covers the entire blackboard and takes up significant page space in her notebook (Figure 7.6). All students, however, through their questioning, seem to be trying to enlarge the space of what is possible or allowed while attempting to integrate the new elements of mathematical discourse into their pre-existing knowledge and discourse models.

These student questions were all answered authoritatively in the classroom dialogues. However, they continued their dialogic life in the space offered by the research interview. The research space thus offered an opportunity for students to give voice to and engage with their ongoing struggles with their own internally persuasive utterances, those of their peers, and the authoritative word of their teacher and mathematical discourse. Students expressed dissatisfaction with the authoritative words of their teacher. Their questions and ongoing dialogues with responses deemed to be ambiguous and insufficient emerged from their deep desire to understand mathematics. In the excerpts below I follow the contours of the “contradictory emotions” and “agitated and cacophonous dialogic life” that accompanied the internally persuasive word initially uttered by Marian in the first observed class.

S.I.1

- | | | |
|----|--|----|
| I: | You asked why is two to the zero equal to one right? | 19 |
| I: | Why did you ask that? | 21 |

Marian:	Because normally when you umm multiply it you will get something other than zero so...	22
Marian:	I am not sure why you put zero...	24
Allison:	Yeah I was wondering bout it cause I thought it would have been zero because you know like when you multiply by zero you get zero? This is the first time ah ever knowing that how the rule will be one. Cause I never did the power to the zero when I used to do volume and area it always used to be the power of two or the power of three and that's all I ever really did.	56
S.I.3		
Katija:	I mean, 2 to the power of zero means 2 by 0, and anything by zero is zero, so I don't understand why 2 by zero is one I don't know where they get the one from?	122
Marian:	Maybe they divide it ...you'll get one.	123
Parvati:	But why is it...?	125
Katija:	Where the one come from? I doh understand? Maybe because is one 2?	126
S.I.2		
I:	And did you all find that answer satisfying?	51
Naobi:	I didn't find it satisfying at all.	55
Naobi:	...because the way miss explained it I thought it didn't make complete sense.	57
Naobi:	But miss did not explain completely, well miss did not explain completely in a way that was satisfactory to me.	63

Though the answers that students received to their questions in the classroom were authoritative, it is in uttering the questions themselves that the internally persuasive word begins to challenge the uninterrupted transmission and authority of mathematical discourse. The internal dialogues of students finds a temporary home in the space offered by the research interview. Here students find room to express and begin to interrogate the authoritative discourses that they are receiving. They are also able to begin to interrogate each other's reasoning. Here their words do not "dry up." Rather, they

release a deluge that reveals the turbulence of their intellectual and emotional struggle to understand.

Though the authoritative word of mathematical discourse gradually gains acceptance as students come to rely on the authority of rules and laws, it is the internally persuasive words of students themselves that continue to reverberate in students' inner dialogues. The internally persuasive word though is given little (or no) further privilege in the authoritative space of the classroom and the creative potentialities that exist for further dialogue and disruption of unsatisfying authoritative discourse remain as yet under-productive and unrealized.

Student views of Teacher Actions that are Internally Persuasive

Saraswati, through her pedagogical acts, works to create internally persuasive moments that serve to counter (or perhaps complement) some of the authoritative aspects of the discourse she represents, transmits and must work within. Two examples of these acts include her movement and interaction with many individual students all around the classroom and her movement of the classroom gaze off students who answer incorrectly while correcting homework. Both of these actions, among others, influence students' conception of Saraswati as a "nice," "good," "friendly" or caring teacher.

Answering questions in class and presenting working/homework at the blackboard were common elements of the authoritative discourse of this mathematics class at the beginning of the school year. Several students expressed some anxiety about this, including feelings of embarrassment when they made a mistake under the evaluative gaze of the class and their teacher. In Lillian's case this results in apprehensiveness towards asking questions in class. She thus waits on Saraswati to come around to avoid the gaze

All of the students I spoke to, with one exception, said that they were enjoying their mathematics class. Many described it as fun and attributed this primarily to the actions and personality of their teacher. There is a strong social element to this teacher-student relationship, as Lillian says, she talks to them “as friends” not just as students. Talking to the teacher is important to these students and they appreciate that Saraswati works at making them feel comfortable doing so. Saraswati is described as being happy and the classroom environment that she creates is one where students are able to be “loose not tense” and do not feel negatively when they get things wrong as they “know” they will learn from their mistakes. In this way students’ anticipation of an enlarged relationship with their teacher is fulfilled and mathematical discourse, despite its authoritative nature, takes on some of the internal persuasiveness associated with their teacher’s actions.

Giving everybody a chance.

Another characteristic of Saraswati’s pedagogy that seemed to be internally persuasive for students was her practice of having every student attempt and present at least one homework question. Thus, while a significant portion of class time is used to correct homework and evaluate students’ work, there is an important social dimension to the activity. This dimension relates to the fact that students entering Form One come from different primary schools and so do not know each other. Thus, giving every student an opportunity to speak might be viewed as important in allowing students to share their mathematical identities and to allow others in the class to begin to come to know their classroom colleagues. Providing every student with an opportunity to speak (talk) and share is thus important in building the mathematical community of this classroom.

In the interviews students generally seemed to appreciate the fact that everyone received such an opportunity to demonstrate what they had learnt, to deepen their own understanding or to receive individual attention from the teacher if they were having difficulty. This is congruent with students' conceptions of a 'good teacher' discussed in Chapter 6 as one who ensures that students understand the material as well as one who is understanding of students' difficulties.

The internal persuasiveness of giving everyone a chance seems to be related to a concern for fairness and equity as suggested by some of the statements below:

S.I.4a:

I: So what do you think of Ms. Ousman's way of giving everybody a chance... 5

Naobi: ...I think it's fair because if I was one of the children who didn't comprehend it as quickly as I did I would feel a little left out, so I appreciate every teacher who has done that because they trying to give everybody a chance, but sometimes it annoys me...

6

Bridgette: I think that is fair that everyone could get a chance to do it, cause everyone will get a chance to be able to understand it more. S.I.4b 9

In the classroom interaction it was important to the students that everyone be seen to be treated equally and in accord with their need for understanding. Saraswati's discourse move which allowed everyone an opportunity to present their attempt at a question is one way that this equality was manifested. In this way too students see and become aware of their teacher's concern for students' understanding. Students' concern for fairness is internally persuasive in that it provisions those "ever newer ways to mean" as it dialogizes their understanding of the classroom context. This is a subject I take up in the next section.

Students views of other Students' Utterances that were Internally Persuasive.

...Discourse models are deeply implicated in "politics"...anything and any place where "social goods" are at stake, things such as power, status, or valued knowledge, positions, or possessions.

(Gee, 2004, p. 84)

...one's position within discourse is never fully achieved...individuals are always weighing their perceptions of their own position within the discourse against what they assume others perceive of their position (Mills, 1997). (Triandafillidis & Potari, 2005, p. 104)

In these first few weeks of the school year at Isabella High School some of the highest academic achievers from a number of different secondary schools have come together in a single classroom. The primary school discourse is one where intense competition and struggle to secure a space at schools like this one have been valued. In the secondary school environment some of the same social and discursive forces that functioned in primary school were still at play. Emerging from a history of competition and certainty regarding one's academic ability, students seemed to be struggling to situate themselves in relation to their new peer group and to foster or maintain an academic identity among their teachers as being very competent. Competition persisted among students for valuable social goods in the classroom economy. These goods included the teacher's attention and perception, as well as their peers' perceptions and being seen as an authority in the classroom.

As Holquist (1990) notes, in tripartite dialogue, the relation is most important since, "without it the other two would have no meaning. They would be isolated, and the most primary of Bakhtin's *a priori*s is that nothing is anything in itself" (p. 38). For some of these students, Naobi in particular, this positioning of the self in relation to the other, whether the other is other members of the class or the teacher, is critically

important to the construction of their identity in this environment. It gives them meaning. The unknown in the interactions among students in the classroom is not a mathematical quantity or relation, though there is evidence of mathematical uncertainty in other dialogues, the unknown here is how one is related and relates to others in this new social network. In the dialogues between students, their teacher and between students and myself there is an attempt to uncover this relation, to position oneself in relation to others.

One of the most important social goods at stake in the classroom economy is the teacher's attention. As explored previously (Chapter 6), students invest their attention with an expected payoff in understanding. An internally persuasive element of classroom discourse thus seemed to be the disproportionate amount of attention that some students seemed to command from the teacher. In several classes Naobi and Aaliyah had requested and/or been invited by their teacher to share things they had learnt or to demonstrate methods for the class (CO5, CO6, CO7). Their combined utterances over the period on site accounted for approximately 32%, roughly one third, of all student utterances, most of which were directed to the teacher. Their unique role as temporary didactic authorities in the class and the amount of attention that they had received there seemed to be the source of some tension and antagonism. In the classroom this expressed itself in the form of teasing. I wondered, however, about the conversations that were accompanying this discursive element:

S.I.5b:

- | | | |
|-------------|--|----|
| I: | Do you all think that some people in the class are getting too much attention? | 42 |
| Lillian | Yes. | |
| & Michelle: | Yes. [laughs] | 43 |
| I: | And how does that make you feel? | 44 |

Lillian:	Left out, because they didn't really come up with it, they just saw it in the book and just explain it.	45
Michelle:	Well it kinda gets us angry sometimes and we feel left out...	48
Jasmine:	Naobi is just get me vex.	151
Katija:	She too rude, she does argue and then say "miss I not arguing with you eh".	154
Katija:	She could get anybody angry.	156
Jasmine:	She always right.	157
S.I.6		
I:	So do think some people in class are getting too much attention?	47
Rose:	Sometimes, because some people tend to question authority a little too much and they try, I not saying it wrong to find new methods of working out things, but sometimes they just overdo it with having all the attention drawn to them.	49

The students in these interviews seemed to express frustration, alienation and sometimes anger which was directed at Naobi in particular. They were critical and disapproved of what they viewed as dishonest claims to being mathematical authorities and the monopolization of the teacher's attention and time. They felt "left out", "angry" and "vexed". Lillian was unhappy with students claiming to have discovered something that was presented in the textbook or was not really their discovery. She felt that this was dishonest. Jasmine, Katija and Rose interpreted Naobi's interaction with teachers (in mathematics and other classes) as being rude, argumentative and attempting to encroach on, question or undermine the teacher's authority. Rose also admitted disliking that they received a disproportionate amount of attention from the teacher and the class. Students' actions and words thus come to take on deep significance for others in the classroom. Indeed in the case of Katija and Jasmine above, Naobi's utterances are re-voiced, they are thus half theirs and "half someone else's" (Bakhtin, 1981, p. 345), and in this case their

own utterances are used to demonstrate their developing perceptions of these individuals and their actions. Their utterances, including gestures, mannerisms and intonations are meant to parody these individuals. They reflect conceptions of other students' identities that they are coming to hold.

Students' anger is internally persuasive in the sense that it is important in their developing understanding of other students' identities and in their struggle with their own internally persuasive discourses which is necessary to their becoming and to their relationships with these individuals in later classroom interactions. Though not strictly 'mathematical' these internally persuasive moments for students are an important part of the social context of the classroom in which they operate as they relate not only to their own becoming but to the becoming of the classroom community. They reflect the fact that in the classroom economy, in which the teacher's attention is seen as a valuable social good, those who attempt to monopolize this good risk the ire of their colleagues.

Students' words of the sort expressed above were also internally persuasive for Naobi in particular as she reacted to and struggled to maintain her academic identity.

S.I.5a

I: So how do you think other students feel about the amount of attention that you all get in class? 78

Naobi: Well they attack me verbally, not in mathematics because they don't want to do it when you have the camera, but they attack me verbally and I'm supposed to talk to miss about that today. And just because a child is the class president they feel that she should be the one, the star of the class. I is just answer, I doh try to be the star of the class.79

Naobi: They tell me 'Naobi you shouldn't be answering so much all the time', but when miss ask a question you doh put up yuh hand to voice your opinion, but you telling me. I want to move on. [angry/impatient] 86

For Naobi, students' comments about her outspokenness in class are interpreted as personalized "verbal attacks." Her attempt to engage with the hurtful words of students evokes strong feelings of anger. These words are incongruent with how she sees herself and she struggles to maintain the integrity of her academic identity. The inter-weaving of hers and others' words together with the internal struggle to maintain her identity suggest that these comments are an important aspect of an internally persuasive discourse for this student.

Following the assessment exercise and classroom review of the questions, in our final interview, Naobi made a statement that put into perspective for me many of her utterances and the responses of members of the class.

Naobi: So normally when I do mathematics I am assured of myself cause when I walked out of the room for SEA I told my mother, 'mommy I get a hundred in maths', and I got a hundred in maths...this is the first time that I get a test and I wasn't certain I wasn't re-assured that I did what I did. I didn't know where I stood, when I hand up the test I didn't know where I stood.

S.I.7-55

One of the terminal points of the dialogic struggle between internally persuasive discourses involving students is revealed in the utterance above, "I didn't know where I stood, when I hand up the test I didn't know where I stood." In addition to their questions, that reveal their struggle to come to understand, and their teacher's inclusive and caring pedagogy, what is important and internally persuasive for students is a secure knowledge of their relation to one another in the classroom. Part of what seems to be significant for students is figuring out where they stand in relation to their teacher, their peers and their mathematical ability, i.e. their positioning in the dialogue.

Teacher

As a teacher Saraswati is bound to and by many discourses many of which are authoritative. Through her pedagogical actions she works to create moments that are internally persuasive for students. However, students' feedback in the form of their utterances and performance on the assessment exercise also provide Saraswati with discursive elements that operate in an internally persuasive manner.

Changing Conceptions of Students

In the last chapter I looked at the authoritative nature of evaluations and in the previous section I explained how this was important for students' mathematical identities and "knowing where they stood." In this section I wish to suggest that the results of assessments are also meaningful and internally persuasive for the teacher. In our final interview (T.I.6), which occurred after Saraswati had marked, and returned students' papers, we discussed what stood out about the test as well as individual student's performance.

Saraswati: ... a couple people stood out for me, which was Naobi, Allison, Katija...Jasmine, I don't know if it's a...well I noticed that the really quiet ones did extremely well. So like for example, Jasmine, you don't hear her in class she got total, Francine, she got total, um...Ivanna, she sits next to Diana, she got total, um who else, Elizabeth, who sits next to Jasmine and Michelle, small little one who sits next to the other Jasmine, and they just so quiet and the more outspoken ones who you know, I don't want to say anything out of the way but, the more outspoken ones didn't do as well as I thought they would of.

60

I: They made mistakes...?

61

Saraswati: ...Yeah...like Naobi got 19 [out of 38], and she made some big mistakes there, Katija had gotten 28, um Jane had gotten 28 as well, I kinda expected them to do a little better,

sits in front of Aaliyah, um, Allison surprised me, because normally when we correcting homework I notice like on two occasions she didn't do the homework and um she always had some excuse you know why she didn't do the homework so I was just kinda surprised at her mark, she got 35. She is one of those, yuh know,...undercover scholars.

62

I: So what you mean by undercover scholar?

63

Saraswati: No, well she always looks so disorganized and yuh know, personally I thought that the reason she didn't do homework was probably she didn't understand or she just didn't think that it was important, but um, I mean she had some, genuine, reasons, it sounded pretty genuine, so, I dunno. She strikes me as one of those, yuh know, slack children...

64

After a relatively short period of time, three weeks, Saraswati has begun to form conceptions of individual students' abilities and classes them according to categories based on their outspokenness in classroom dialogue as well as their performance on assessment tasks. She observes that students who have been quiet in class have generally performed better than those who were more outspoken and is surprised that Allison whom she describes as being "disorganized" and "slack" has done really well while others who have been vocal in class such as Naobi and Aaliyah have not done as well as she had expected. She has begun to construct individual representations of students' mathematical identities and abilities. These identities are partially formed from her dialogues with students in the form of classroom questions and conversations and to a large extent, by their response to her teaching – the revision exercise. Both of these responses function as internally persuasive discourse in the sense that they cause her to reorganize her own discourse models of what constitutes a good student. From students' behavior in class and their performance on the exam Saraswati comes to correlate student

performance with student outspokenness. Quieter students generally performed better than the more outspoken ones. She is also surprised at Allison's performance since she viewed her as a student who did not put as much effort into her work. It is this unanticipated surprise, an ability to re-evaluate one's prior conceptions of individual identities, which suggests the internally persuasive dimension of classroom evaluation for teachers.

Hearing Students' Responses

The dialogic struggle between authoritative and internally persuasive discourses that Bakhtin posits as central to one's ideological becoming and the openness to dialogue of both teachers and students in the pedagogical moment and relationship, leaves individuals vulnerable to feelings of rejection, anger, disappointment and hurt. These feelings too can be internally persuasive and indicate the existence of "an agitated and cacophonous dialogic life" (Bakhtin, 1934/1981, p. 344) from which emerges an enlarged understanding of our self and our relationship to others.

Over the course of the three weeks Saraswati's conception of the class as anxious and shy began to change as they interacted with each other. By the end of the second week Saraswati no longer used anxious to describe the class, instead she reflected:

Saraswati: ...I think they are asking, I mean they did ask a lot of questions in the first week, I think they are becoming a little more open and they are asking more questions, some of them feel a little more comfortable to try and explain what they learnt or what they know and that kind of thing. I think they for form ones they are pretty open...

This candor, described as openness, displayed by the students of this form one class in asking questions is atypical in Saraswati's experience. These heteroglossic moments

interrupt the smooth transmission of the authoritative mathematical discourse as she has experienced it in the past and occasion a re-examination of her discursive practices:

Saraswati: ...I was just thinking why are they asking me so many questions, cause the last two form ones that I had never asked that many questions...

Attending and engaging with these questions caused some uncertainty and anxiety as Saraswati was unsure what this meant. Students' words began to function as internally persuasive discourse for Saraswati as they began to intermingle with her own words and came into contact with the authoritative words that she had inherited and which offered her no assistance. They persuade her of the need for continued dialogue with herself. What does it mean? Is it that they do not understand her lessons or the material? Are they having difficulty? Will they continue to like her and think of her as a good teacher or will she be remembered as a horrible teacher? As she begins to question herself, it is her identity as a mathematics teacher that becomes exposed and vulnerable.

In order to help Saraswati appreciate some of the conceptual difficulties that students were having I reviewed portions of students' video interviews with her where they described the difficulties that they had been having with several of the rules and methods that they had learnt in class. These had not been privileged as part of the continued classroom discourse where they had emerged in interaction with the authoritative word but, as discussed above, continued to live and mean in the space afforded by the research interview. Saraswati's response to seeing and hearing these students' utterances was unanticipated and internally persuasive for me and I address this in a later section.

T.I.3

Saraswati: God this is really, I don't know [inaudible]...[frustrated tone]

- I: So what do you think? 52
- Saraswati: Why am I in the teaching profession? Umm, what do I think is happening? With what? 53
- I: In the class. So do you think that they understand you before having looked at this? 54
- Saraswati: Well I thought that [shrugs] most of them were but I guess not. 55
- Saraswati: Nobody really told me that they don't understand...I only know because of you...They must really think I am a horrible teacher? 90

After reviewing the incidents Saraswati begins to question her efficacy and re-evaluate her career choice. What she has heard (and seen) from the students appears to have hurt her feelings and surprised her since she has had no questions regarding these issues from students during class. However, it is the authoritative classroom discourses themselves that offer no space (or time) to deal with students' dissatisfaction and desire for deeper understanding. The discourse to which Saraswati belongs, for the discourse does not belong to Saraswati, is one in which her authority and identity as a teacher are wedded. Because of the hierarchical nature of authoritative discourse, whose authority lies in the past, it cannot be challenged in the present. For Saraswati then, as the representative of and conduit for the authority of mathematical discourse, the responsibility for students' failure to properly internalize and reproduce the discourse must lie in her own actions rather than in the structure and content of the discourse itself. In this way both the authority and the discourse itself are preserved and what yields to the authoritative discourse is one's sense of self. In addition, because being liked is an integral part of Saraswati's identity as a teacher she takes the students' comments regarding their incomplete understandings as a personal criticism of her teaching and herself.

Two days later in a follow-up interview (T.I.4) Saraswati expresses sadness, frustration and anger about some of the comments she had heard from the students in the interviews.

Saraswati: ...after hearing comments about, from students about your teaching, like Naobi, I don't explain to her satisfaction, you know it really does bring your self esteem a little low, it brings it down basically and personally I am beginning to dislike teaching. I'm wondering if it's really for me? 43

Saraswati: ...I've noticed I like to teach, personally I realized, and I knew I always wanted to do this, especially when I was at [another High School], to do some sort of remedial work, and teaching this form one class I realize that's probably what I really want to do because I don't like teaching really smart children. 45

Saraswati: ...I feel they are coming with some sort of impression about me, some sort of stigma and somehow I can feel it in their body language. 55

Saraswati: It's just different, how you are is different. I just feel they are looking at me, Mr. Khan knows. 59

Saraswati: I think it's bad but from the comments they've made...I guess being a human being I feel kind of upset at them for assessing... 62

The students' words have not left her, they continue to interact with and influence Saraswati's prior discourses. They begin to influence her understanding of herself and her own preferences. In the earlier part of the interview she continues to assess her decision to become a teacher as what she has heard from the brief segments of student interviews leads her to question herself. She likes to teach but from her experiences with *this* particular class she is not sure that she likes teaching "really smart children." She is not happy and is upset not only with their assessment of her, but also the fact that they are assessing her, and that she *knows* about it. The rigid boundary of authoritative discourse, in which it is taboo for students' to express their lack of understanding for teachers to

hear, has been transgressed. Students' internally persuasive words penetrate Saraswati's consciousness, precipitating an ideological accommodation and re-organization. This though is an emotionally painful process and is possibly due to her feeling that her love and openness have been rejected or not fully received, that students see her as a "horrible" or "bad" teacher. If this is true, then based on her discourse model of teaching and learning mathematics, students will not want to pay attention and will not be engaged in class, consequently she would have failed them.

Engaging with the internally persuasive word is not always easy or painless. The process of one's ideological becoming is never a simple matter. As Liston (2000), who contrasts love and despair in teachers' lives, suggests, "Good teaching entails a kind of romantic love of the learning enterprise; it is motivated by and infuses others with a love of inquiry. Teaching in and with this love is a vulnerable undertaking, one that leaves the teacher open to pain and rejection..." (p. 82). Teaching with love he says, entails a "vulnerability," an offering of "naked humanness," that within an authoritative climate often leads teachers to despair. Saraswati's emotions upon hearing and reflecting on students' efforts to understand their own mathematical difficulties as well as their implied assessment of her teaching are powerful factors in her ideological reassessment of herself and her choice of profession. They are deeply meaningful because of the vulnerability occasioned by her desires to be liked and seen as a good teacher, and her openness and efforts to accommodate students' needs in her classroom.

Researcher

The speaker strives to get a reading on his own word, and on his own conceptual system that determines this word, within the alien conceptual system of the understanding receiver; he enters into dialogical relationships with certain aspects of the system. The speaker breaks through the

alien conceptual horizon of the listener, constructs his own utterance on alien territory, against, his, the listener's apperceptive background. (Bakhtin, 1981, p. 282)

Students' responses

Students' responses to the question of competition for the teacher's attention were internally persuasive for me and I would like to comment on how I felt during this portion because of the way it affected me as a researcher. In asking the question I had expected that the students might have thought that other students would have felt jealousy and maybe resentment. I was not prepared for the hurt and anger in Naobi's and the other students contributions. I was uncomfortable being a part of this discussion though I also felt responsibility for initiating it via my questioning. I had expected that I might encounter strong affective emotions from students regarding mathematics content or their mathematics teacher but was taken aback by these utterances about other students. I was conscious as well of trying not to be drawn in to providing any sort of tacit support, agreement or reinforcement of their statements.

Initially, I was apprehensive about examining that portion of the data. I did not want to involve myself in what I viewed as the political struggles among class members. However, as I have come to appreciate more deeply, dialogue is *always* political. It is always a struggle for power, and an occasion demonstrating the use of power. Though 'power relations' is not a theme I examine directly in this thesis they are, nevertheless, important as students negotiated and created their social spaces. In this thesis I am also aware that many students in the class did not and do not have a voice in the sense of being able to describe their interpretation of mathematics class, of what was internally persuasive for them. In order to collect what I considered to be rich data in a relatively short period of time on-site I deliberately chose and invited students who were more

vocal in class to be interviewed. While I did invite students who seemed quieter in class to be interviewed and repeatedly said that anyone could come to talk about math class if they wished, none ever came. Furthermore, while I did not deliberately exclude anyone, my conscious inclusion may also have served as a sign among students of the type of student I was interested in.

Understanding Saraswati's Response

Saraswati's response to hearing students' interview comments proved to be internally persuasive for me as a researcher and prompted my own ideological reassessment. Her strong emotions caused me to become anxious and to wonder about my culpability in causing these feelings. I felt partially responsible since I had decided to show these clips in order to help Saraswati to understand the conceptual difficulties that students had been having. I was also struck by her statement, "Mr. Khan knows," which seemed to cast me as an accessory to the students' assessments. Compounding these feelings was my own belief, based on students' utterances regarding what they liked about Saraswati's approach to mathematics class and my observations in the classroom, that Saraswati was a well liked teacher by the majority of the class and that they genuinely liked her as an individual.

Reactivity refers to the ways in which the presence of an observer influences the activities of participants (Patton, 2002). From a Bakhtinian perspective reactivity is always already a part of a communicative act that is dialogical. As Holquist (1990) points out the observer for Bakhtin is, "simultaneously an active participant in the relation of simultaneity" (p. 21). However, since "an event cannot be wholly known, cannot be seen from inside its own unfolding as an event" (p. 31) then, "in order so see

ourselves we must appropriate the vision of others” (p. 28). In my interactions with Saraswati and the class my established role was that of observer. However, the dialogic perspective demands that I de-center myself and attempt to see how others saw and interpreted my utterances by making them the center, the observer. In doing this I acknowledge that my own utterances have contributed to the dialogue that is socially and historically constructed and created by this community. Further, I see and hear that my own words and actions have social and discursive power beyond that to which I ascribe intentionally to them, for dialogue is never mine alone. Indeed, while, “we cannot choose not to be in dialogue” (Holquist, 1990, p. 29) with the world, as researchers in the field and in the classroom we *must choose* to be responsible for our dialogues and how they are potentially felt by those we dialogue with.

The internal persuasiveness of Saraswati’s utterances forced me to re-evaluate the ethnographic perspective that I had chosen to adopt as a researcher and which I had moved beyond in allowing Saraswati to view the short segments of student interviews. Working within my own culture with a teacher whose history was not unlike my own in many ways proved to be problematic in that I could not achieve the necessary degree of ‘outsiderness’ to conduct purely ethnographic work. Working in a politically (and emotionally) charged context such as a school in mathematics education research I felt that it was important to assist Saraswati with understanding her students’ mathematical difficulties. This was not a research goal. Rather, it was simply one mathematics teacher attempting to assist another, one human being responding to another in an unfolding dialogue. Understanding this aspect of my own self now, I see then that in doing research in my own culture I cannot adopt the stance of the classic ethnographer. Rather, other

orientations such as action or collaborative research may be more productive and better aligned with my own views of myself, my goals as an educational researcher and the realities of research in my island's context. Thus for me, one of the most important aspects of the learning that occurred from this study was the understanding of my own orientations and predilections as a researcher.

Like Saraswati and mathematics knowledge, my own knowledge of ethnography and classroom based research was an example of a received authoritative discourse. In the field I became a representative of this inherited discourse, one which I was not yet adequately prepared to interrogate and simply followed. In dialogic interaction with this community however, my own relation to this discourse as a distant descendent became apparent. While the literature on ethnography had initially proved internally persuasive for the purposes I proposed, the authoritative boundaries it posited were inadequate to my situation in the field as it unfolded. Again, like Saraswati, in these moments when the authoritative boundaries of the discourse in which one exists are revealed, one is forced to make ideological adjustments. These adjustments can involve either the abdicating of our responsibility to attend to other's words and feelings, a retreat to the comfort and security of the authoritative word, or, if we are open to receiving other's words, cause us to engage dialogically with these words, to incorporate them into our ideological consciousness, to make them "half ours." To be open in this way as a researcher also leaves one vulnerable. Perhaps it is a necessary vulnerability?

Many of the incidents I have chosen to highlight in the analytic portion of the thesis in some way or another were internally persuasive for me as a researcher. They represent my choice of what I considered to be most meaningful to myself as a researcher as well

as what I thought likely to be most meaningful to the community of scholars and interested individuals with whom this thesis hopes to dialogue. The thesis itself does not aim to be authoritative in its tone or content, but to attempt to occasion those “ever newer ways to mean” that characterizes internally persuasive discourses.

Summary

In this chapter I have attempted to acknowledge some of those discourses that emerged from but were not privileged in classroom discourse. I highlighted elements of these discourses that I suggest were internally persuasive for students, their teacher and for myself. For students, their own as well as others’ questions, their teacher’s caring pedagogical actions and their perceptions of other students’ utterances were all internally persuasive. For Saraswati, students’ questions, their expressed lack of understanding and their comments on her teaching were sometimes painfully internally persuasive. For me, students’ vitriolic comments about other students and Saraswati’s emotional anguish at hearing students’ responses were internally persuasive. These internally persuasive moments are important in the ongoing formation of the identities (and ideologies) of participants in this mathematics class; they are influential in the ways that they potentially serve to direct later classroom relationships and utterances among students and their teachers. They thus serve as an important facet in the construction of the mathematical community of this class.

CHAPTER 9

UNFINISHED AND INEXHAUSTIBLE DIALOGUE

Discourse lives, as it were, beyond itself, in a living impulse toward the object; if we detach ourselves completely from this impulse all we have left is the naked corpse of the word, from which we can learn nothing at all about the social situation or the fate of a given word in life. (Bakhtin, 1981, p. 292)

...discourses in general, and educational discourses in particular, may become dangerous if left unchanged for long periods of time. Their ostensible innocence, their reputation for being “just words,” endows discourses with more power to hurt than can be found in many overt weapons or in declared adversaries. Discourses may turn us into oppressors even if we are acting with the best of intentions. (Sfard, 2005, p. 337)

I am faced now with the task of how to bring this conversation to a close, to bring it all together, to tie up the loose ends, explain what it all means to me and what the point of this discourse analysis was even as it continues to open up further possibilities and occasion ever newer ways to mean for me. However, part of being in dialogue with others is the necessity of committing oneself to silence so that others may have the opportunity to speak and to be heard. This commitment to a critical and *‘care-full’* listening, which is not to be equated with the monologism associated with silenced dialogues, arises from a sense of gratitude for having been given the opportunity to speak and to be heard at all.

This thesis (mirroring the study itself) has taken a meandering course over the discursive terrain that is a mathematics classroom. Its purpose was to examine how the polyphonic discourse of a mathematical community related to the development/ evolution of mathematical conceptions among members of the community. Certainly, the discourse in the classroom that I observed was polyphonic in that there were numerous voices:

individual as well as institutional, contemporary and historical. These voices and their utterances functioned at different times, in different ways and for different groups, as authoritative as well as internally persuasive discourse. This polyphonic discourse was important not only in the development of individuals' conceptions of mathematics (and in my case of mathematics education research) but, as importantly, in the development of individual and community identities and relationships. In this chapter I revisit the questions proposed in Chapter 1 as I relate what was learnt. I also consider what this means and could mean, and, suggest avenues for further meaning making.

What was Learnt?

The first question that this study addressed was “What conceptions of mathematics do participants in the mathematical community of a beginning secondary school classroom initially bring to the discourse?” Students and teachers in this beginning secondary classroom professed a diverse set of conceptions of mathematics that reflected the diversity of their individual socio-historical trajectories. In addition, there were many similarities which came from their being participants in larger societal discourses. As similar studies (e.g. Schoenfeld, 1989) have found, students professed a belief in mathematics as a discourse about numbers, rules and solving problems whose utility is largely confined to future employment and everyday consumer activities. Mathematical activities evoke strong affective responses and students described enjoying an acceptable level of “challenge” but disliking “complicated” problems. The majority of students held positive self concepts about their mathematical ability and attributed this to external reinforcement through examinations as well as their own internal assessments of how easily they understood. Learning and doing mathematics for students required an

investment of student attention in class and diligence at home with an expected payoff in mathematical understanding as represented by test scores. In addition, students described the existence and need for mastery of problem solving skills, which included comprehension and metacognitive awareness, as well as a disposition to diligence and to view mathematics as useful, and enjoyable in order to do well. Typical mathematics classes were described in terms of an authoritative script of sequential and unalterable events while students' ideal class was characterized by a desire for an expanded relationship with their teacher as well as for greater feelings of positive affect. Finally students' views of a good mathematics teacher was one who had more than a command of disciplinary and pedagogical content knowledge but also had relational competencies of patience, kindness and was understanding of their needs while helping them to understand mathematics.

There were many congruencies between Saraswati's conceptions of the subject and those of her students. These congruencies included viewing mathematics as rule based and with a problem solving orientation and the importance of paying attention. Saraswati's experiences of horrible mathematics teachers at this level and at university inform both her conceptions of mathematics as a domain, her view of herself in relation to mathematics as well as her conceptions of mathematics pedagogy. Her emphasis was on preparing students to succeed in terminal examinations. However, she was also desirous that students have fun learning mathematics and develop "morally, spiritually and ethically."

Congruencies between students' and their teacher's conceptions of mathematics meant that both understood and worked with an implicit didactic contract in which

investments of attention and effort were expected to lead to concomitant mathematical understanding. As a result of this understanding of the didactic contract, students were familiar with their expected roles in the class and what doing and learning mathematics required. Such an understanding was part of their prior discourse and partially accounts for their previous success in mathematics. Saraswati too had an understanding of what she wanted to achieve with these students but also acknowledged the constraints inherent in the institution of school such as time and access to resources.

Among the other research questions that this thesis sought to address were “What were the major discourse patterns in a beginning secondary school mathematics classroom?” “Who were the voices in these discourses?” “What did they say?” “How were they interpreted?” And “What type of relationships did these discourse patterns foster?” In Chapters 7 and 8 I presented the case for and described examples of authoritative and internally persuasive discourse elements as two types of patterns. I addressed the other research questions through an analysis of some of these elements.

On the surface, based on classroom observations alone, the discourse pattern in this mathematics class over the three weeks demonstrated many authoritative elements. These elements included a fairly well defined sequence of activities to individual lessons and the topic of number bases in general. This structure of explanation, example, exercise and evaluation was also found in the layout of the textbook upon which Saraswati relied, both to inform her disciplinary content knowledge as well as her pedagogical strategies in teaching this topic. Evaluative activities in the form of correcting homework and an end of lesson review exercise helped to initiate students into an authoritative secondary school mathematical discourse, which was considered by

Saraswati to be important to their success in later terminal examinations. Several examples or cases were related that demonstrated the authoritative way in which students' questions were answered in class and how, over time, students came to rely on the authority of "rules," "laws," or, in Saraswati's case, "mathematicians in the past," as a means of justifying the mathematical procedures that they were asked to perform without having to understand. Other authoritative elements included the use of cloze type questions in IRE sequences and the ambiguous use of the collective pronoun "we" by the teacher. The result of immersion in this authoritative milieu is that both teacher and students seemed to be learning a discourse of *doing without understanding*.

The authoritative nature of the discourse in this classroom was not wholly unexpected given the larger and more general societal Discourses regarding the role of education and its relation to success. What students learnt from the authoritative elements was procedural fluency in mathematics, i.e. the ability to perform a given algorithm to arrive at an answer whose validity depended on having performed the algorithm correctly. Such fluency is important in that it enables students to perform well in terminal examinations. This practice, however, acts to reinforce students' conceptions of mathematical activity as being rule based and requiring rote memorization as opposed to understanding. For students, however, the desire to understand the underlying mathematics manifested itself in their classroom questions. Such questions though were authoritatively silenced by the monologic authority inherent in statements such as "it's *just* a law" and explanations that "it *just* ends." One might reasonably surmise that over time students may cease to vocalize such questions in class as the answer is already

known – “it’s a law” or they may cease to ask such questions altogether and come to see mathematics as more and more esoteric.

Saraswati’s heavy dependence on the textbook to direct her pedagogy as well as to inform her knowledge and understanding of the mathematical material reflects a common situation in Trinidad and Tobago and is reported elsewhere in the literature (Handal, 2003). What was interesting to me was the way in which the authoritative structure and tone of the textbook chapter were replicated in the structure of the individual lessons and in the topic of Number Bases as a whole. Both textbook authors and mathematicians were historical and unimpeachable authorities whose voices were a significant part of the discourse of this classroom. Though Saraswati represented these authoritative voices in the class her utterances both in and out of the classroom suggested that she too felt unable to challenge them.

In heteroglossic social situations, however, authoritative discourse is never absolute. Thus, despite the authoritative nature of the classroom there were several moments and episodes that I have described as being internally persuasive for students, their teacher and for myself. Indeed, I feel that this is one of the important contributions that this thesis makes to the research literature on communication in mathematics classrooms – the recognition and description of internally persuasive discourse elements for students, their teacher and the researcher.

Internally persuasive discourses operated continuously just below the authoritative classroom surface. Student questions, for example, served to (temporarily) interrupt the simple monologic transmission and reproduction of authoritative discourse while simultaneously revealing the emotional and intellectual discontent that was deeply

felt by both students and Saraswati as their desire for understanding went unfulfilled. These ephemeral moments, when students' and their teacher's desire to understand mathematics is manifested, present opportunities for a different dialogue among participants and have the potential to significantly influence individuals' conceptions of mathematics and the mathematics classroom discourse.

In addition to their questions about mathematical concepts, much of what was internally persuasive for students involved interpersonal communicative acts by their teacher and their peers. Students viewed many of Saraswati's actions, especially her talking with them "not just as students but as friends," as internally persuasive. This led many to describe her as fun and nice, and the classroom environment that she created as comfortable, and loose. What students seem to find internally persuasive about Saraswati's pedagogy is the feeling of being cared for. This provides some evidential support for Noddings' (2005) call for a pedagogy of care in school. Such caring is important, as Saraswati suggested early on, for students' continued engagement with mathematics. Perhaps it is through an appreciation of the pedagogical power of care that the authoritative elements that dominate mathematics discourse, and which fail to provide satisfaction, might be (more successfully) challenged.

Students also found internally persuasive Saraswati's decision to give everyone a chance to dialogue with the class by presenting their answers to homework questions verbally or written on the chalkboard. For many students this was a matter of equity. However, students also felt offended by some students who seemed to be monopolizing the teacher's (and the class's) attention. This interpersonal friction between individuals I suggest was internally persuasive as students attempted to locate their position in relation

to others in the classroom community and constructed mathematical identities for themselves and others. Though not linked directly to a mathematical discourse, this construction of mathematical identities occurred in and emerged from the social interactions between students. Students' 'talk' constructed not only their own identity but also the identities of their peers. Such identity formation is an integral part of an adolescent discourse of becoming especially in a new environment such as secondary school. The actions and utterances of peers played a significant role in shaping intrapersonal and interpersonal identities and consequently the nature of the relationships within the classroom community.

For Saraswati, students' responses to her teaching functioned as internally persuasive discourse. From her interactions, observations and assessment of students via testing and homework Saraswati also constructed mathematical identities of individual students in her class. However, it is hearing and seeing students' struggles with mathematical concepts and their implicit and explicit statements about her teaching that seemed to be most meaningful for Saraswati. These responses cause her to dialogue with herself as she re-evaluates her decision to become a teacher at this particular school. Teachers also are always in a process of becoming and re-shaping their identities. I have suggested that this response is partly the result of Saraswati's openness to her students and her desire to be liked and that such openness leaves one vulnerable. Teachers like Saraswati, also need to feel that their care and effort are received, appreciated and reciprocated by their students. They too need caring for. Authoritative structures and their associated discourses offer little hope for such a relation. Rather, it is through acknowledging the internal persuasiveness of one's emotions and desires and engaging in

ongoing dialogues that the ways in which such relations might be developed could emerge.

Internally persuasive moments, which found no permanent place within the authoritative structures of this particular mathematics classroom, flourished in the space offered by the research interview. This is interesting and significant and suggests a wider role for the research interview than the recording of participants' conceptions. Like the classroom, the research space offers a place to make meaning both for the researcher and the participants. Unlike the classroom, here both authoritative but especially internally persuasive discourses ought to be and were privileged. Indeed while I am tempted to argue for the creation of spaces with similar dynamics I question the feasibility and viability of such a project within the existent authoritative structure of schooling in general. Despite this caveat I nevertheless view the recognition and further development of the internal persuasiveness of such spaces as an important avenue for further dialogue.

Saraswati's response to hearing and seeing students' responses to her teaching was internally persuasive for me as a researcher as it required me to acknowledge my own contributions to the dialogue in this community, to consider my own evolving identities as (graduate student) researcher and teacher and to reflect on the dialogic framework that I have adopted throughout this thesis. The internal persuasiveness of Saraswati's utterances and those of her students required me to attend more deeply to the inherent ambiguity of communicative acts, to acknowledge the vulnerability of openness when in dialogue and to seek to understand the concomitant responsibilities of such attention and acknowledgement. In order to do this there is a need to elaborate my

theoretical framework further to include these elements of ambiguity, vulnerability and responsibility as they relate to communication in general.

Ambiguity, Vulnerability and Responsibility

Students' questions and Saraswati's internally persuasive pedagogical acts operated within the authoritative discourse of the mathematics classroom. My own research actions and the conversations which ensued also operated within the authoritative space of the ethnographic qualitative interview. Internally persuasive moments, however, emerged from a passionate engagement and openness to others. This type of engagement is explored by Pryer (2001) who looks at the Eros of teaching and learning, (and which I extend to researching) defining them as erotic acts. She conceives of Eros as the motivation for engaging in the process of forming relations with others. Teaching, learning, knowing (and researching) are thus cast as erotic acts where Eros is understood as "an opening and receiving, an attunement to the unique gifts of the other...an endless becoming, a perpetual birthing" (Pryer, 2001, p. 78). The opening up in school (and research) is often described mechanically as in one opening the other rather than organically, a mutual and responsive opening of one to the other. Such opening is usually surrounded by discourses of fear and mistrust. Indeed one might argue that individuals in schools (and possibly research courses) are taught to fear, question and (over)regulate their (penetrative and emotional) potencies, to fear theirs and others' vulnerabilities. Such positions often leave students and teachers (and researchers) unsatisfied and impoverished.

Eros though, Pryer suggests, offers hope, through its unpredictable and untamed nature. It directly challenges the authoritative culture of techno-rationality and

instrumental efficiency of schools. Instead, eros “flows into the cracks in the system, and the cracks are everywhere, in the hearts of all teachers and students” (Pryer, 2001, p. 86) and to which I would add researchers. It is from this flow of eros, of passionate engagement, that internally persuasive discourses make themselves felt.

An understanding of Eros in the communicative relationship and the responsibilities which are thus incumbent upon those of us whose work involves understanding our own and others’ communicative acts is explored by Todd (2003) and provides a useful end to this section of the thesis. Though Todd does not identify researchers in her paper, what she discusses is equally true for educational researchers who work in the classroom as it is for teachers. For Todd (2003) the authoritative and normative roles of teachers and students (and researchers) “make it appear that teachers and students (and researchers) do not regularly participate in an economy of erotic affect” (Todd, 2003, p. 35). Drawing on the scholarship of Emmanuel Levinas, who describes eros as an “ambiguous communicative practice” she writes,

The Levinasian emphasis on responsibility instead mean(sic) that subjectivity and responsibility reveal themselves only in relation to an other and therefore emerge from a signifying encounter with absolute difference that cannot be predicted beforehand...the ethical lies within the very ambiguity of communication, within that which slips our cognitive grasp and possession. Ambiguity is not so much a matter of misunderstanding what is being said (or expressed) as it is a matter of the impossibility of ever knowing the other through these significations. For Levinas, communication is inherently ambiguous because it gestures beyond any stable meaning toward the very otherness of the other that marks her as radically distinct from myself. And it is this relation to the other as one of unknowability where the ethical promise – and risk – of ambiguity lies. (p. 33)

The passionate emotions that are evoked as students speak about their struggle to understand and resist the authoritative word and their anger at inequities involving other students’ actions; as Saraswati speaks about hearing students’ comments; and my own

reactions to Saraswati's utterances and emotional gestures, arise from this sort of communicative ambiguity. For Levinas, according to Todd, it is precisely this ambiguity in communication which accounts for the internal persuasiveness of others' discourses. He thus points the way to an understanding of eros as a *quality* of relationality and not merely as a *type* of relation. Hence acknowledging this ambiguity becomes important to understanding our responsibilities to others in our acts of communicating. For Todd (2003) this communicative ambiguity "asks us to attend to the concrete communicative practices through which responsibility emerges, as opposed to offering prescriptions of what those practices ought to look like" (p. 32). Responsibility then, "involves a radical openness in communication and an attending to the (unknowable) particularity of the other that lies behind the words spoken, the deeds committed. In short, responsibility involves transcending what is manifest in speech or gesture" (Todd, 2003, p. 34).

Such radical openness in communication is what I was privileged to observe as students, teachers and I engaged in communicative acts with varying degrees of ambiguity in and out of the classroom. This openness and ambiguity though, steeped in an "economy of erotic affect" in which teacher, researcher and students had others' interests and well being at heart, requires an acknowledgement of the vulnerability that existed in each group. The presence of such vulnerability though is not a liability. Rather it is a necessary part of the process of one's ongoing ideological formation. Recognizing and valuing it as such is a critical step in beginning to fulfill our responsibilities as teachers, researchers and students to one another.

The authoritative word however makes no provision for ambiguity, uncertainty or vulnerability and portrays responsibility as fidelity. However, in failing to acknowledge

that students and their teachers, researchers and their participants, occupy and operate from ambiguous and thus vulnerable places, the authoritative word reveals its own vulnerability. Eros, moves in these ambiguous spaces to connect and construct internally persuasive discourses that challenge the authoritative word by revealing its inadequacy. Eros' persuasiveness derives from its drawing our attention away from egoistic concerns towards a deeper understanding of our interdependencies and 'intervulnerabilities'. The internal persuasiveness of Eros thus compels us to choose to speak on behalf of ourselves and others when we recognize those occasions where authority is used as a means to silence dialogue, disenfranchise, disempower or oppress. It not only demands that we speak to these issues of injustice, its '*resourcefulness*,' in drawing other internally persuasive discourses to itself and reinvigorating them, provides us the means to act 'differently.'

The challenge for schools, teachers, students and researchers who struggle within and against authoritative discourses is to learn how to attend to this ambiguity in one's own as well as others' communicative practices without fearing the vulnerability of being open that it entails and without neglecting the responsibilities that are inevitably revealed. In order to meet this challenge there is the need for a reciprocal and reflexive relationship (a dialogic one) between dialogue and pedagogy.

A Relationship between Dialogue and Pedagogy

There have been and continue to be calls for a more dialogic pedagogy (Morrell, 2004) and to view curriculum as dialogue (Renshaw & van der Linden, 2004). Together these seek to open up spaces in curriculum and pedagogy for the realization of the possibilities when heteroglossia is acknowledged and privileged. A dialogic pedagogy is

more equitable and in many ways more desirous than a monologic one. Such an orientation makes us more concerned about issues of voice; silence and representation; about equity and the quality of dialogue. In the opening up of pedagogy to and through dialogue there is the potential for more voices to contribute to building communities. However, simply having more voices is not sufficient and dialogic pedagogy is not a panacea for the authoritative ills of educational Discourses. Indeed prescriptions for a dialogization of pedagogy are incomplete and run the risk of tending towards the monologic especially if and when they fail to acknowledge the ambiguities, uncertainties and vulnerabilities of inter and intrapersonal communication. For with more voices, there is an even greater demand and even scarcer resources for care-full listening. There is the risk that as dialogic pedagogy privileges and provides students (and teachers and researchers) more means and opportunities to speak that it reduces the opportunities available for them to learn to become attentive to what their own and other voices are actually saying. There is then a reflexive and reciprocal need for dialogue itself to open up to and through pedagogy.

The opening of dialogue to and through pedagogy is a less explored topic in the dialogic literature though Lefstein (2004) makes a compelling argument for “‘pedagogicizing’ dialogue” (p. 7) as he outlines a pragmatic approach to dialogue that takes into account the inherent asymmetries and structures of modern schools. Attending to the pedagogy of dialogue teaches us not only to listen to what is being said but to consider how it might mean (differently) to others and how such meaning, though unintended and unanticipated, can result in pain or oppression. The pedagogical opening

of dialogue thus implies that there is always something (more) to be learnt from dialogue and that what is to be learnt can be learnt through further dialogue.

This necessary opening of dialogue to and through pedagogy involves understanding the ways and means through which dialogue teaches us about our self and about others. It requires of us a recognition of the potential for unintended (and sometimes painful) consequences of our ambiguous communicative practices even when we attempt to think and act critically (Ellsworth, 1989); and consequently attempts to persuade us that we do have incumbent responsibilities to others (and to self) with whom we engage in dialogue if we wish to continue the (dialogic) conversation. In this way attention to the pedagogy of dialogue teaches us to how to listen carefully, answer responsibly and act ethically in a dialogic community. It also teaches us that we must continually work at re-orienting ourselves to practices of listening to those with whom we dialogue. Attending to the pedagogy of dialogue sensitizes us to the potential impact of our utterances on the individuals with whom we dialogue and what then is required of us. Our concern then is with an “ethic of answerability” (Renshaw & van der Linden, 2004) and not simply authoritative accountability.

Dialogic pedagogy is necessary to bring into, and thus enrich, the conversation, those voices that have thus far been silenced, neglected or forgotten by authoritative educational D/discourses. It privileges the speaking subject. Attending to the pedagogic and internally persuasive dimensions of such dialogic pedagogy though is a necessary and complementary posture in which we learn or are taught to listen closely to what is said and actively engage in discovering the meanings and the untapped potentials that exist for what is said to mean differently. Dialogic pedagogy then already anticipates and

articulates its need for the response of an attentive and meaning making audience who seek what is pedagogic in the dialogic.

Pedilogy

The internally persuasive word is either a contemporary word born in a zone of contact with unresolved contemporaneity; such a word relates to its descendents as well as to its contemporaries as if *both* were contemporaries...that word's semantic openness to us, its capacity for further creative life in the context of our ideological consciousness, its unfinishedness and the inexhaustibility of our further dialogic interaction with it. We have not yet learned from it all it might tell us; we can take it into new contexts, attach it to new material, put it in a new situation in order to wrest new answers from it, new insights into its meaning, and even wrest from it new words of its own (since another's discourse if productive, gives birth to a new word from us in response). (Bakhtin, 1981, pp. 346-347)

In following the advice of Flyvbjerg (2004) during the research and analysis process, I kept my eyes open in the hope of learning something. However, were this my only means of making meaning I think I would simply have observed (and reported on) the authoritative nature of the mathematical discourse in this classroom. However, as Davis (1996) suggests for mathematics teaching, and which applies equally well to mathematics education research, one needs to consider what can be gained by temporarily privileging the sense associated with another sensory modality, listening. But as necessary as it is to listen it is as important the organ that we listen with. Were I to have kept *only* my ears open I would have heard (and possibly reported on) many of the things that I have come to categorize as internally persuasive. However, I think it is a more radical openness of the sort described previously that not only allowed me to 'see' and 'hear' these discourses but as importantly to 'feel' them, i.e. to begin to attend to the

ambiguity and vulnerability inherent in communicative acts and to acknowledge my own responsibilities and vulnerabilities.

My Voice

At the very beginning of this thesis I described the voice that I chose to speak with as “a human being, in dialogue with and responding to other human beings.” Thus the thesis already anticipates a response, even if such response fails to enter my own perceptual horizons. In keeping with the Bakhtinian dialogic tradition in which the thesis is written I offer a word that is internally persuasive for me that emerged from many different but related internally persuasive discourses in which I am enmeshed. I offer the term ‘pedilologic’ to describe this voice. It is a voice that seeks primarily to speak *with* as well as to speak *to* (in this way it is always directed by someone to someone) it is not a voice that attempts to speak *for*, to stand in place of, especially as such voices typically erase or obliterate the actual speaker and his/her intentions.⁷ The aim of the pedilologic voice is to maintain an ongoing conversation, a dynamic and reflexive tension between the dialogic and the pedagogic as each opens itself to the other. The need to maintain this ongoing conversation reflects the problematic situation in which there are increasing, almost authoritative, calls for more dialogic pedagogy, i.e. for dialogue to open up pedagogy, while there is almost no acknowledgement of the role that pedagogy itself must play in opening up dialogue to its responsibilities.

The internally persuasive word that I suggest to describe this reciprocal and reflexive relationship between dialogue and pedagogy is pedilogy. Its composition is *pedis* (foot) and *logos* (word). *Pedilogos* then might be defined as *the walking word*.

⁷ This is one of the reasons that I have decided to include participants’ voices in the numerous excerpts.

Pedilogy then is conceived of as a dialogical relation that seeks to maintain a productive dynamic tension between walking *and* talking (*and* listening). The word (speech /thought /expression /utterance/dialogue) walks in that it achieves distance in both time *and* space and is active in one's ideological development. The walk (pedagogy/curriculum/research) is also a word in that each step is part of a larger story and full of its unrealized potential to mean. A word walks *and* a walk words. Pedilogy then is about walking *and* talking; doing *and* thinking; speaking *and* listening; being *and* becoming.⁸ Pedilogy moves the task of the teacher/learner/researcher as a source of **information** and action to an awareness of being perpetually **in formation**, always becoming, an incompleteness and ambiguity that is always already a potentiality.

Having written *this* thesis I am also deeply aware of how this thesis has written me, how it has revealed me as researcher as much as I have attempted to reveal the research situation. On becoming aware of the powerful (and taken for granted) role of communication in mathematics classrooms and research settings one becomes aware not only of one's own communicative ambiguity, i.e. how what one says and does can potentially mean substantially more or significantly less than was intended, but one begins to actively acknowledge one's own communicative inadequacies and one's potential for causing pain and suffering. I find myself slightly detached from myself, listening to and choosing carefully my own words, cognizant of what my eyes, arms, legs, fingers and breathing are doing and what they might potentially convey/betray about my thoughts.

⁸ This is grounded in Deleuze's (1995) philosophy of multiplicities in which the conjunction AND is given priority over the verb 'to be', "AND is neither one thing nor the other, it's always in between two things, it's the borderline,...a line of flight or flow...it's along this line of flight that things come to pass, becomings evolve, revolutions take shape" (Deleuze, 1995, p.45).

I also find myself attending more closely to these same things in others when they speak and am not as surprised when there seem to be miscommunications or misunderstandings. For in our communicative transactions there are a multitude of meanings that are '*missed*' and sometimes, perhaps even often, we do miss the understanding behind others and our own communicative acts. This awareness I think makes one more sensitive and compassionate to the ambiguity inherent in all communicative acts and requires an ongoing dialogue so that one retains the possibility of obtaining incrementally better understandings of what others mean and what they intend their utterances to mean. Outside of this, meaning is either unproblematic and assumed by the individual or authoritatively received.

Situated in this historical present when authoritative discourses abound across the sociopolitical landscape from schools at all levels to the highest political offices I have also become aware of the low tolerance for ambiguity in what are monological, hierarchical and, ultimately, silencing systems. At the same time I have come to appreciate (and value) more fully the latent generative potential of ambiguity (as well as to acknowledge its potential for painful consequences). Systems with no (or low) tolerance for such ambiguity also tend to have a low tolerance for disruptions. They are simultaneously sensitive, yet resistant to change.

Despite the attempts of normalizing authoritative discourses, the ability of language (and semiotic mediators in general) to mean 'other' than what we intend them to mean ought not to be seen as a reason for despair and hopelessness. That we are not able to truly 'convey' meaning, or to know if the meaning we have intended to convey is the same meaning that was understood, does not suggest the death of meaning, but rather

the potentially overwhelming diversity of meaning suggests a source of great human comfort, potential joy as well as hope – since the consequence is that (unpredictable) meaning ever emerges in the (ongoing) conversation, the dialogue.

Beyond token acknowledgement and tolerance, ambiguity in communication must be actively valued, not as a means for justifying obfuscation and excusing oppression (though these possibilities must also be acknowledged) but as a means of inviting ourselves and others back into dialogue and conversation in order to deepen our understandings of each other and our selves. This is one route to developing and sustaining care and compassion in our pedagogical practices. Perhaps it may also be a route to justice and joy?

Suggestions for Further Research/Analysis/Dialogue

I offer three suggestions for further research. The first is an acknowledgement of one of the limitations of the present study – time. A longer period on-site or the ability to make multiple visits over the year would have allowed me to better understand how these discourses continued to interact and how they related to individual's and the community's becoming and understanding of itself. Thus, future studies should attempt as far as possible to engage in more longitudinal research. The second suggestion is that mathematics education research should begin to focus on what is internally persuasive for students and teachers in mathematics teaching and learning more generally and not merely report on authoritative structures. For example, does what is internally persuasive change with age level or are there constants? My final suggestion is for a deeper analysis of the internal persuasiveness and potential for meaning making of the research interview setting for both participants and researchers.

There are many other ways in which this study could have been framed. There are many ways that this type of study could be and should be read and listened to. For example, how might this study look and sound through the lens of critical theory? Given the history of Trinidad and the modeling of the education system on the British system, a postcolonial reading would also likely reveal further meaning. There are also interesting psychoanalytic elements regarding the classroom gaze – that of students, the teacher and the researcher – and desires that deserve a closer reading (see for e.g. Walkerdine, 1988). In addition much of what I have written seems to resonate with emerging socio-political discourses in mathematics education discussed in Chronaki and Christiansen (2005). The dialogic framework, however, provided the initial means to ‘look’ and ‘listen’ to the participants and myself in this study. And having looked and listened carefully, it suggests that there is much more yet to learn by looking and listening differently.

Thoughts on Mathematics Educational Practice

What is my response to the question that might be posed by teachers who, identifying with Saraswati, ask: “What can I do?” In this situation it is easy to succumb to the temptation to provide authoritative prescriptions that would place me in a hierarchical position similar to those “mathematicians in the past” and which would deliberately overlook and oversimplify the complexities of individual teaching situations. My pedilologic orientation though, requires that such a response emerge through dialogue. In the absence of a ‘real’ conversant I offer some reflections on where such dialogues would begin for me.

Listen

As teachers there is the need for us to listen more closely and openly to what is

being said (and especially what is not being said) by those with whom we interact – our students, colleagues, administrators, curriculum documents and textbook authors – in order to communicate more effectively from the positions where we stand. Hearing can be painful. However, by cultivating the ‘care-full’ practice of listening to ourselves and others we may better be able to answer the question of what to do.

A return to student questions that we have difficulty answering, even after the fact, can key us in to our own incomplete mathematical understandings. These incomplete understandings are only deficiencies if we continue to accept and make no attempts of our own at understanding. Students’ and our own questions are opportunities to seek out, listen and dialogue with others. Listening does not have to be a solitary activity. There is a need to resist the impulse to prematurely silence questions, including our own, through appeals to deaf authorities. It is in valuing and listening more closely to these ambiguous moments when we do not yet ‘know’ fully, not as ends in themselves, but for the potential they harbor for meaning making and learning that we create spaces (and time) to do differently.

Remember

It is easy to forget why we decided to become teachers especially when we have internalized authoritative discourses that measure and disclose how far we are from what is held up as how we ought to be and which circumvents any ambiguity by prescribing what must be done and how it is to be done. Saraswati describes in several interviews her memories of why she became a teacher and what her own experiences of teachers were. This remembering reveals a discrepancy between her stated goals as a teacher and her concern for being complicit in reproducing an unsatisfying mathematical discourse. Our

pedagogic desires, often frustrated by conditions outside of our control, remain an important, and often neglected, index by which we can engage questions of what to do by beginning to reflect on what mathematical discourses do (and have done) to those who learn and those who teach.

Risk

Those who begin to consider doing something different run a risk. They run the risk of ridicule, of failure (by others' standards), and a risk of becoming painfully aware of their own and others' vulnerabilities and suffering. As a researcher, any simplistic prescription that I offer entails more risk to teachers' daily lives than to my own. For me not to acknowledge this risk is an unacceptable omission. Risk entails acknowledging and embracing those vulnerabilities, uncertainties and ambiguities that have the potential to transform situations and individuals in unexpected ways. Listening and remembering are risks.

Without risk though can there be any hope for meaningful change? 'What can I do?' thus begs the questions 'What can I risk?' or rather 'What am I prepared to risk?' and 'What can potentially be gained?' There are no easy answers to these uneasy questions, especially as any answer necessarily comes without a guarantee. What though do we risk by not risking? And do we risk too much by risking too little?

Responsibility

Having listened, remembered and risked we must be prepared to accept the responsibilities for ourselves, our utterances, the discourses, the communities and the identities which we have shaped and which have shaped us. Accepting this responsibility too is a risk, but it is a necessary one if we are to 'do' anything differently. Authoritative

discourses while allowing recipients to eschew or abjure their responsibilities, elides their vulnerabilities. Re-appropriating our responsibilities then, provides a foundation for speaking and acting with and on behalf of those whose vulnerabilities are exploited, including ourselves, by dominant educational discourses.

These thoughts addressed to teachers reflect my own journey in this thesis of listening, remembering, risking and accepting my responsibilities. It expresses what I hope I would do in my own pedagogic spaces.

Conclusion

Talk builds communities. However, certain kinds of talk have a greater potential to build more ethically minded, responsible and caring communities than others. In struggling to create conditions where the possibility of lifelong, democratic access to powerful mathematical ideas (English, 2002) can be realized we must be mindful that mathematics, like many disciplines, has an authoritative nature. This authoritative discourse in mathematics classrooms becomes problematic when it attempts to silence the internally persuasive discourses of participants, denying them agency and authorship of their mathematical identities. Dialogic discourses that are open to and are actively and reciprocally opened by pedagogic discourses, in my opinion, are critical for imagining and building ever ‘better’⁹ types of educational communities.

In ending this thesis, and my turn in the conversation, I draw one last time on Bakhtin (1981) who states that “An independent, responsible and active discourse is the fundamental indicator of an ethical, legal and political human being” (pp. 349-350). I hope this sentiment resonates with you as it does with me, offering a challenge to the

⁹ ‘Better’ is an ambiguous and loaded term. One must ask better for whom and in what ways. By better I mean an ongoing attempt at continuous improvement along the dimensions of ethical behavior, personal and communal responsibility, democratic principles, love, care and justice for all.

multiple identities and responsibilities that we have to the diverse communities to which we belong as well as an opportunity to continue to dialogue, to uncover, discover and recover ever newer ways to mean and do and be and...

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APPENDIX A

Letter of Information for Principal

Isabella Girls High School
San Fernando, Trinidad W.I.

Dear Mrs. _____,

Re: Dialogical relations in a mathematics classroom.

I am writing to request the participation of your school in research aimed at understanding how conceptions of mathematics are shaped dialogically in beginning secondary school students. I am a graduate student in the Faculty of Education, Queen's University working towards my Masters degree in education.

My research topic aims to understand how the discourses of early secondary mathematics classrooms relate to the development of conceptions of mathematics among early secondary students. As such I will require a period of approximately three weeks on your campus in order to observe and record via video and audio tapes the dialogues that occur in a single Form One mathematics classroom. I will seek the permission of parents, students and the associated teacher to conduct this research in the manner described. I will do my best to be as unobtrusive as possible so as to cause as little disruption to the normal running of the school and these classes.

In the second part of my research I will return to my campus and continue to dialogue with a sample of four students from this class and the mathematics teacher via electronic mail and instant chat programs until the end of the first term. This I believe will be less disruptive than remaining on your campus for the equivalent period. I anticipate that these participants will utilize no more than two hours per week each on these activities.

None of the data will contain the name of the school, or the identities of the students or teacher. Data will be secured in a locked office and confidentiality is assured to the extent possible. You also have the right to withdraw your support and request that your school's data be removed from the study at any time.

I do not foresee risks in your school's participation in this research. Your participation and that of the students and teacher is entirely voluntary. Students and teachers will not be obliged to answer any questions that they find objectionable, and you are assured that no information collected will be reported to anyone who is in authority over you. You are free to withdraw your support from the study without reasons at any point, and you may request removal of all or part of any data gathered.

This research may result in publications of various types. The name of the school will not be attached to any form of the data, nor will the names or the identities of the teacher and students be known to anyone tabulating or analyzing the data, nor will these appear in any

publication created as a result of this research. Pseudonyms will replace all names on all data protect your school's identity and that of the participants. If the data are made available to other researchers for secondary analysis, these identities will never be disclosed.

This research has been cleared by the Queen's University General Research Ethics Board.

I would be happy to provide additional details of my research and answer any unresolved questions or address any concerns that you may have. While in Trinidad I can be contacted in the following ways:

Telephone: 650-3366 or 652-8413 or

e-mail: 4skk@qlink.queensu.ca or stevepc@hotmail.com

If you have any questions about this project, please contact my supervisor, **Dr. Geoffrey Roulet** at **1-613-533-6000 ext. 74935** or rouletg@educ.queensu.ca. For questions, concerns or complaints about the research ethics of this study, contact the Dean of the Faculty of Education, **Dr. Rosa Bruno-Jofré**, **1-613-533-6210**, or the Chair of the Queen's University General Research Ethics Board, **Dr. Joan Stevenson**, **1-613-533-6081**, email stevensj@post.queensu.ca

I look forward to your response.

Sincerely,

Steven Khan

Principal's Consent Form

Re: M. Ed. Thesis Research

For: **Mr. STEVEN KHAN** of the School of Graduate and Professional Studies, Faculty of Education, Queens University

Title: Dialogical relations in a mathematics classroom.

- I have read and retained a copy of the letter of information concerning the “Dialogical relations in a mathematics classroom and all questions have been sufficiently answered.
- I am aware of the purpose and procedures of this study, and I have been informed that classroom dialogues will be recorded by audiotape and videotape.
- I have been notified that participation is voluntary, that I may withdraw my support at any point during the study without any consequences to my organization or its members and I may request removal of data.
- I understand that, upon request, I may have a full description of the results of the study after its completion.
- I understand that the researcher intends to publish the findings of the study.
- I have also been told the steps that will be taken to ensure confidentiality of all information.
- I am aware that if I have any questions about this project, I can contact Dr. Geoffrey Roulet at 1-613-533-6000 ext. 74935 or rouletg@educ.queensu.ca
- I am also aware that for questions, concerns or complaints about the research ethics of this study, I can contact the Dean of the Faculty of Education, Dr. Rosa Bruno-Jofré, 1-613-533-6210, or the Chair of the General Research Ethics Board, Dr. Joan Stevenson, 1-613- 533-6081, email stevensj@post.queensu.ca.
- I agree to allow Mr. Steven Khan access to this campus to conduct a research study entitled “Dialogical relations in a mathematics classroom”, conducted through the Faculty of Education at Queen's University.

Please sign one copy of this letter of consent and return to Steven Khan. Retain the second copy for your records.

I HAVE READ AND UNDERSTOOD THIS CONSENT FORM AND I AGREE TO PARTICIPATE IN THE STUDY.

Principal's Signature: _____

E-mail address: _____ Date: _____

Telephone Number(s): _____

Please add your mailing address in the space below ONLY if copies of publications resulting from this study are requested.

Parental Letter of Information

Dear Parent/Guardian:

I am writing to request the participation of your daughter in research aimed at understanding how conceptions of mathematics are shaped in beginning secondary school students. I am a graduate student in the Faculty of Education, Queen's University working towards my Masters degree in education having previously taught at the secondary level in Trinidad for five years.

Your daughter is one of a group of Form 1 students selected as a potential participant for a research study, conducted as part of my Masters Thesis research. The study is entitled **“Dialogical relations in a mathematics classroom”**. The research has the support of your child's teacher and the school principal. Moreover, the research has been cleared by the Queen's University General Research Ethics Board.

The aim of this letter is twofold. First, it will describe the purpose and method of the research study. Second, it will request that both you and your daughter agree, in writing, to participate in the study. Please indicate your decision to participate in the study on the attached *Letter of Consent* and return it to me or your child's teacher at your earliest convenience.

The purpose of the study is to investigate how classroom communication influences students' developing conceptions of mathematics. The proposed method of the study requires that I observe and record classroom communication for a period of approximately three weeks at your daughter's school. These recordings will be both video and audio tapes of the dialogues that occur in a single Form One mathematics classroom. I will do my best to be as unobtrusive as possible so as to cause as little disruption to the normal running of the school and your daughter's class. These recordings will be transcribed and kept confidential.

In the second part of my research I will return to my campus and continue to dialogue with a sample of four students from this class and the mathematics teacher via electronic mail and instant chat programs until the end of the first term. This I believe will be less disruptive than remaining at the school. I anticipate that participants in this part of the research project will utilize no more than two hours per week each on these activities. Your daughter would be required to e-mail once per week and meet once per month for an online interview via a chat program. You will thus be able to record and view these online interviews.

The observation and interactions involves students in no more risk than normal classroom activities. Hence, there are no known physical, psychological, economic or social risks to your daughter associated with participation in this research.

Agreement on your part to allow your daughter to become a part of the study in no way obligates your daughter to remain a part of the study. Participation is voluntary, and your

daughter, or you on their behalf, may choose to withdraw from the study at any time. You also have the right to have all or part of your daughter's data removed from the study at any time. Further, participation or non-participation will not affect any school mark or report card that your child may receive.

I intend to publish the findings of the study in professional journals and report them at conferences. At no time will the actual identity of the participants be disclosed. Pseudonyms will be assigned to protect the identities of the school, the student participants and the teacher.

It is important to me to protect the privacy of the people who participate in the project. Here is how I will protect your privacy:

- No names will be used in the data or published work.
- Only myself and my supervisor will have access to the video and transcript data.
- The data will only be used for research purposes.
- None of the data will appear in your child's school records.
- The data will not be used to evaluate your child in any way.
- Copies of data will be kept on an external storage medium.

If you consent to participate in the research study, I ask that you and your daughter sign the accompanying consent forms and return them to me as soon as possible. Your signature on these forms tells me that you understand the procedures involved and that you consent to participate. Please keep this letter for your information.

I would be happy to provide additional details of my research and answer any unresolved questions or address any concerns that you may have. While in Trinidad I can be contacted in the following ways:

Telephone: 650-3366 or 652-8413 or

e-mail: 4skk@qlink.queensu.ca or stevepc@hotmail.com

This research has been cleared by the Queen's University General Research Ethics Board.

If you have any questions about this project, please contact my supervisor, **Dr. Geoffrey Roulet** at 1- 613-533-6000 ext. 74935 or rouletg@educ.queensu.ca. For questions, concerns or complaints about the research ethics of this study, contact the Dean of the Faculty of Education, **Dr. Rosa Bruno-Jofré**, 1-613-533-6210, or the Chair of the Queen's University General Research Ethics Board, **Dr. Joan Stevenson**, 1-613-533-6081, email stevensj@post.queensu.ca

Sincerely,

Steven Khan

GENERAL CONSENT FORM

Re: M. Ed. Thesis Research

For: **Mr. STEVEN KHAN** of the School of Graduate and Professional Studies, Faculty of Education, Queens University

Title: Dialogical relations in a mathematics classroom.

Student's name (Please Print): _____

- I have read and retained a copy of the letter of information concerning the "Dialogical relations in a mathematics classroom and all questions have been sufficiently answered.
- I am aware of the purpose and procedures of this study, and I have been informed that classroom dialogues will be recorded by audiotape and videotape.
- I have been notified that participation is voluntary, that I may withdraw my child/ward at any point during the study without any consequences to myself or my child/ward and I may request removal of her data.
- I understand that, upon request, I may have a full description of the results of the study after its completion.
- I understand that the researcher intends to publish the findings of the study.
- I have also been told the steps that will be taken to ensure confidentiality of all information.
- I am aware that if I have any questions about this project, I can contact Dr. Geoffrey Roulet at 1-613-533-6000 ext. 74935 or rouletg@educ.queensu.ca
- I am also aware that for questions, concerns or complaints about the research ethics of this study, I can contact the Dean of the Faculty of Education, Dr. Rosa Bruno-Jofré, 1-613-533-6210, or the Chair of the General Research Ethics Board, Dr. Joan Stevenson, 1-613- 533-6081 74579, email stevensj@post.queensu.ca.
- I agree to participate in the study entitled "Dialogical relations in a mathematics classroom", conducted through the Faculty of Education at Queen's University.

Please sign one copy of this letter of consent and return to Steven Khan. Retain the second copy for your records.

I HAVE READ AND UNDERSTOOD THIS CONSENT FORM AND I AGREE TO PARTICIPATE IN THE STUDY.

Signature of Student: _____

E-mail address: _____

I HAVE READ AND UNDERSTOOD THIS CONSENT FORM AND I AGREE TO ALLOW MY CHILD/WARD TO PARTICIPATE IN THE STUDY.

Signature of parents/guardians: _____ / _____

Date: _____

Telephone Number(s): _____

E-mail address: _____

Please add your mailing address in the space below ONLY if copies of publications resulting from this study are requested.

Postal Address(es): _____

Consent Form For The Use Of Videotape

The videotape will not be viewed by anyone other than myself or my thesis supervisor unless you release it intentionally by signing this form.

Please fill out either Section A or Section B

Section A

I agree to allow Mr. Steven Khan to use the videotaped classroom sessions for one or more of the following purposes:

1) Publication in a Journal

Signature: _____

2) Demonstration to Students

Signature: _____

3) Demonstration at a Conference

Signature: _____

Date: _____

I understand that neither my name nor my child's name will be associated with the work.

Section B

I prefer not to have the videotape of my child shown in classes or at conferences or reproduced in any form.

Signature: _____

Date: _____

Letter of Information for Teacher

Dear Sir/Madam:

I am writing to request your participation in a research study aimed at understanding how conceptions of mathematics are shaped in beginning secondary school students. I am a graduate student in the Faculty of Education, Queen's University working towards my Masters degree in education having previously taught at the secondary level in Trinidad for five years.

The aim of this letter is twofold. First, it will describe the purpose and method of the research study. Second, it will request that you agree, in writing, to participate in the study. Please indicate your decision to participate in the study on the attached *Letter of Consent* and return it to me at your earliest convenience.

The purpose of the study is to investigate how classroom communication influences students' developing conceptions of mathematics. The proposed method of the study requires that I observe and record classroom communication for a period of approximately three weeks at your school. These recordings will be both video and audio tapes of the dialogues that occur in a single Form One mathematics classroom. I will do my best to be as unobtrusive as possible so as to cause little disruption to the normal running of the school and your class. These recordings will be transcribed and kept confidential.

In the second part of my research I will return to my campus and continue to dialogue with a sample of four students from this class and yourself via electronic mail and/or instant chat programs until the end of the first term. This I believe will be less disruptive than remaining at the school. I anticipate that you will utilize no more than two hours per week on these activities. You would be required to e-mail once per week describing your perceptions of what is happening in the classroom and meet once per month for an online interview via a chat program. You will thus be able to keep your own record and view these online interviews.

The observation and interactions involves no more risk than normal classroom activities. Hence, there are no known physical, psychological, economic or social risks to yourself associated with participation in this research.

Agreement on your part to become a part of the study in no way obligates you to remain a part of the study. Participation is voluntary, and you may choose to withdraw from the study at any time. You also have the right to have all or part of your data removed from the study at any time.

I intend to publish the findings of the study in professional journals and report them at conferences. At no time will the actual identity of the participants be disclosed. Pseudonyms will be assigned to protect the identities of the school, the student participants and yourself.

It is important to me to protect the privacy of the people who participate in the project. Here is how I will protect your privacy:

- No names will be used in the data or published work.
- Only myself and my supervisor will have access to the video and transcript data.
- The data will only be used for research purposes.
- None of the data will appear in your teacher records.
- The data will not be used to evaluate you in any way.
- Copies of data will be kept on an external storage medium.

If you consent to participate in the research study, I ask that you sign the accompanying consent forms and return them to me as soon as possible. Your signature on these forms tells me that you understand the procedures involved and that you consent to participate. Please keep this letter for your information.

I would be happy to provide additional details of my research and answer any unresolved questions or address any concerns that you may have. While in Trinidad I can be contacted in the following ways:

Telephone: 650-3366 or 652-8413 or

e-mail: 4skk@qlink.queensu.ca or stevepc@hotmail.com

This research has been cleared by the Queen's University General Research Ethics Board.

If you have any questions about this project, please contact my supervisor, **Dr. Geoffrey Roulet** at **1- 613-533-6000 ext. 74935** or rouletg@educ.queensu.ca. For questions, concerns or complaints about the research ethics of this study, contact the Dean of the Faculty of Education, **Dr. Rosa Bruno-Jofré, 1-613-533-6210**, or the Chair of the Queen's University General Research Ethics Board, **Dr. Joan Stevenson, 1-613-533-6081**, email stevensj@post.queensu.ca

Sincerely,

Steven Khan

Teacher's Consent Form

Re: M. Ed. Thesis Research

For: **Mr. STEVEN KHAN** of the School of Graduate and Professional Studies, Faculty of Education, Queens University

Title: Dialogical relations in a mathematics classroom.

- I have read and retained a copy of the letter of information concerning the "Dialogical relations in a mathematics classroom and all questions have been sufficiently answered.
- I am aware of the purpose and procedures of this study, and I have been informed that classroom dialogues will be recorded by audiotape and videotape.
- I have been notified that participation is voluntary, that I may withdraw any point during the study without any consequences to myself and I may request removal of all or part of my data.
- I understand that, upon request, I may have a full description of the results of the study after its completion.
- I understand that the researcher intends to publish the findings of the study.
- I have also been told the steps that will be taken to ensure confidentiality of all information.
- I am aware that if I have any questions about this project, I can contact Dr. Geoffrey Roulet at 1-613-533-6000 ext. 74935 or rouletg@educ.queensu.ca
- I am also aware that for questions, concerns or complaints about the research ethics of this study, I can contact the Dean of the Faculty of Education, Dr. Rosa Bruno-Jofré, 1-613-533-6210, or the Chair of the General Research Ethics Board, Dr. Joan Stevenson, 1-613- 533-6000 ext. 74579, email stevensj@post.queensu.ca.
- I agree to participate in the study entitled "Dialogical relations in a mathematics classroom", conducted through the Faculty of Education at Queen's University.

Please sign one copy of this letter of consent and return to Steven Khan. Retain the second copy for your records.

I HAVE READ AND UNDERSTOOD THIS CONSENT FORM AND I AGREE TO PARTICIPATE IN THE STUDY.

Teacher's Signature: _____

E-mail address: _____ Date: _____

Telephone Number(s): _____

Please add your mailing address in the space below ONLY if copies of publications resulting from this study are requested.

Postal Address: _____

Letter of Information and Consent Form for ongoing online dialogues

Dear Parent/Guardian:

I am writing to request the participation of your daughter in the second stage of my research project that is aimed at understanding how conceptions of mathematics are shaped in beginning secondary school students.

Your daughter is one of a group of _____ students from her class selected to engage in an ongoing conversation involving e-mail and instant messenger conversations.

Your daughter would be required to e-mail at least once per week and to engage in one online conversation in the months of October, November and December. You will thus be able to record and view these online interviews. I do not anticipate this taking up more than two hours per week. My final interview will occur after term marks are received in December.

I remind you that agreement on your part to allow your daughter to continue to be a part of this study in no way obligates your daughter to remain a part of the study. Participation is voluntary, and your daughter, or you on their behalf, may choose to withdraw from the study at any time. Further, participation or non-participation will not affect any school mark or report card that your child may receive. Please keep this portion of the letter.

Yours respectfully,

Steven Khan

-----Detach and return-----

I agree for my daughter to participate in the online portion of this study entitled “Dialogical relations in a mathematics classroom”, conducted through the Faculty of Education at Queen's University.

Signature of Student: _____

I HAVE READ AND UNDERSTOOD THIS CONSENT FORM AND I AGREE TO ALLOW MY CHILD/WARD TO PARTICIPATE IN THE ONLINE PORTION OF THIS STUDY.

Signature of parents/guardians: _____ / _____

Date: _____

APPENDIX B

Sample Student Questionnaire

Please complete this questionnaire at home and return together with consent forms as soon as possible. Please do not collaborate in answering the questions.

Part 1

Name: _____

Primary School Attended: _____

Do you have access to a computer at home?: _____

Do you have your own e-mail account?: _____

Do you use instant messenger programs?: _____

Which one(s)?: _____

How often do you use instant messenger programs?

Never Occasionally Frequently

How comfortable do you feel using instant messenger programs?

Uncomfortable Comfortable Very comfortable

To whom do you go for assistance with mathematics (Check **all** appropriate)

Friends School Teacher Family

Lessons Teacher Other (Please specify): _____

Part 2

Read through all questions before completing using the space provided. If you require more space use the reverse side of the page. You might choose to describe actual events. Please give as much detail as possible. Please answer honestly. Feel free to omit questions. This is not a test and you will not be graded.

1. What do you like about Mathematics?
2. What do you dislike about Mathematics?
3. What do you think Mathematics is about?
4. Do you think Mathematics is useful outside of school? Explain?
5. Can everyone do Mathematics? Why or Why not?
6. What do you think are the characteristics of a good mathematics teacher?
7. How have you used a mathematics textbook to learn mathematics?
8. Describe your typical mathematics class.
9. What should one do in order to learn mathematics?
10. Describe your ideal mathematics class.
11. What do you think about mathematics homework? Is it easy? Difficult? How long does it generally take?
12. What are the most important things in doing well in mathematics?
13. In your opinion what skills do people who are good at math have?
14. Do you consider yourself good in mathematics? Explain?
15. Is mathematics an important subject to you? Why or Why not?
16. Do you find mathematics easy to understand? Why or Why not?

APPENDIX C



REPUBLIC OF TRINIDAD AND TOBAGO
MINISTRY OF EDUCATION

SECONDARY EDUCATION MODERNIZATION

PROGRAMME

REVISED DRAFT

SECONDARY SCHOOL CURRICULUM

FORM ONE

Mathematics

Curriculum Development Division
September 2002

A NOTE TO TEACHERS

The Ministry of Education through the Secondary Education Modernization Programme is seeking to reform the secondary education system. The draft curriculum documents produced for eight subject areas represent a key element in the current thrust to address the deficiencies identified in the system. These deficiencies include the absence of a common core curriculum for all secondary schools, fragmentation of information and skills provided to students, a lack of connection to the real world and a wide variation in the teaching time accorded to various subjects from school to school.

The new curriculum repairs these deficiencies and further prepares students to meet the rapidly changing demands of the twenty-first century. It is designed to enable all students to achieve the national goals for secondary education. The curriculum documents presented herein will guide the adoption of a more student-centered approach to instruction and the provision of learning opportunities for the holistic development of the student at all levels – development of the total person, morally, spiritually, intellectually emotionally and socially.

The new curriculum is being developed one year at a time. As the material for each year is drafted, it is piloted and revised on the basis of the observations made and feedback obtained.

The Curriculum Documents are organized in three parts. Part One provides the general context of philosophy and aims in which every subject is anchored, and is common to all subjects. Part Two is specific to the subject area and includes specific outcomes and samples of activities and strategies that may be used to achieve them. The rest of the document has been designed to suit the particular needs of each subject area. All the documents include sample assessment strategies, activities and the major resources needed.

Teachers are reminded that instructional decisions must be based on sound, contemporary educational theory, practice and research. The documents presented herein will therefore serve as a guide for the development of instructional programmes to be implemented at the school and classroom levels.

We are confident that this curriculum will significantly enhance teaching and learning experiences in our secondary schools and consequently the achievement of the national educational goals.

Sharon Mangroo
Director, Curriculum Development (Ag.)
September, 2001.

Section 1-1 to 1-10INTRODUCTION

In its commitment to a comprehensive reform and expansion of the secondary school system, the Government of the Republic of Trinidad and Tobago in 1996, adopted the report of the National Task Force on Education as educational policy. The specific recommendations for the improvement of secondary education led to discussions with the Inter American Development Bank (IADB) for loan funding arrangements for a programme to modernise secondary education in Trinidad and Tobago. This programme, the Secondary Education Modernization Programme (SEMP) was formalized and has been designed to:

- address deficiencies identified in the education system;
- establish a firm secondary education foundation that would catapult Trinidad and Tobago into the 21st century assured of its ability to participate advantageously in the global economic village, smoothly traverse the information super highway and utilize cutting edge technology for the competitive advantage it provides;
- allow for adaptation to future demands; and
- produce good citizens.

The deficiencies identified include:

- an unacceptably low level of academic achievement;
- unsatisfactory personal and social development outcomes; and
- curricular arrangements whose major outcomes were linked to the attainment of a minimum of five General passes in the Caribbean Examinations Council (CXC) examination.

The Secondary Education Modernization Programme (SEMP) consists of four articulated components:

- (a) improved educational equity and quality
- (b) deshifting, rehabilitation, and upgrading of school infrastructure
- (c) institutional strengthening, and
- (d) studies and measures for improved sector performance.

This document is evidence of the effort to address component (a) under which curriculum development falls.

THE CURRICULUM UNDERPINNINGS

This curriculum has been informed by the wealth of available curriculum theories and processes. In the Final Report of the Curriculum Development Sub-Component submitted by J. Reece and K. Seepersad, the curriculum is defined, as a “plan for action” or a “written document that included strategies for achieving desired goals or ends.” This is the definition that is applied here. The curriculum is herein defined as the written document that is to be used by teachers to plan effective learning opportunities for students in secondary schools.

Macdonald (1976) declares,

‘Curriculum it would seem to me is the study of “what should constitute a world for learning and how to go about making this world”. As such it is a microcosm... the very questions that seem to me of foremost concern to all humanity, questions such as what is the good society, what is the good life and what is a good person are explicit in the curriculum question. Further, the moral question of how to relate to others or how best to live together is clearly a part of curriculum.’

In essence Macdonald’s statement establishes the basic forces that influence and shape the organization and content of the curriculum: the curriculum foundations. These are

- (a) The Philosophy and the Nature of Knowledge
- (b) Society and Culture
- (c) The Learner
- (d) Learning Theories

These foundations are at the heart or the centre of the dialogue essential to the development of a coherent, culturally focussed and dynamically evolving curriculum. Of course the prevailing philosophical concerns and educational goals provide the base.

PHILOSOPHY OF EDUCATION

The following philosophical statements are at the foundation of the curriculum and are stated in the Education Policy Paper 1993-2003 as follows:

WE BELIEVE

That every child has an inherent right to an education which will enhance the development of maximum capability regardless of gender, ethnic, economic, social or religious background.

That every child has the ability to learn, and that we must build on this positive assumption.

That every child has an inalienable right to an education which facilitates the achievement of personal goals and the fulfilment of obligations to society.

That education is fundamental to the overall development of Trinidad and Tobago.

That a system of 'heavily subsidised' and universal education up to age 16 is the greatest safeguard of the freedom of our people and is the best guarantee of their social, political, and economic well-being at this stage in our development.

That the educational system of Trinidad and Tobago must endeavour to develop a spiritually, morally, physically, intellectually and emotionally sound individual.

That ethical and moral concerns are central to human development and survival. Fundamental constructs such as "decency," "justice," "respect," "kindness," "equality," "love," "honesty," and "sensitivity," are major determinants of the survival of our multi-cultural society.

That the parent and the home have a major responsibility for the welfare of the child and that the well-being of the child can best be served by a strong partnership between the community and the school.

That the educational system must provide curricular arrangements and choices that ensure that cultural, ethnic, class and gender needs are appropriately addressed.

That students vary in natural ability, and that schools therefore should provide, for all students, programmes which are adapted to varying abilities, and which provide opportunities to develop differing personal and socially useful talents.

That we must be alert to new research and development in all fields of human learning and to the implications of these developments for more effective teaching and school improvement.

That the educational system must be served by professionals who share and are guided in their operations by a set of systematic and incisive understandings, beliefs and values about education in general and its relationship to the development of the national community of Trinidad and Tobago.

That there is a need to create and sustain a humanised and democratised system of education for the survival of our democracy.

That the democratisation and humanisation of the educational system are largely contingent on the degree to which the system is professionalised. The nature of educational problems is such that the professional core must be engaged in decision-making with respect to the problems that affect their expert delivery of the services to the clientele and ultimately to Trinidad and Tobago. Professionals must come to experience a real sense of 'control and ownership' of matters educational.

That from a psychological perspective, education is a means of looking out beyond the boundaries of the immediate. It can be the viable means which creates individuals with the intellect and capacity to develop and lead societies, communities, villages, and/or neighbourhoods and families of the future. It should be responsive to and stimulate the searing human spirit and the emphatic quest for human communication, interaction, love and trust.

That learning is cumulative and that every stage in the educational process is as important and critical for the learner's development as what has gone before it and what is to come. As such we must view

educational programming and development in the round, recognising the importance of every rung on the ladder of delivery by intensifying our efforts throughout the system.

THE GOALS OF EDUCATION

Coming out of the articulated philosophy, formal education in Trinidad and Tobago must aim to:

- provide opportunities for all students to develop spiritually, morally, emotionally, intellectually and physically;
- develop in all students attitudes of honesty, tolerance, integrity and efficiency;
- provide opportunities for self-directed and life-long learning;
- provide opportunities for all students to develop numeracy, literacy, scientific and technological skills;
- promote national development and economic sustainability;
- promote an understanding of the principles and practices of a democratic society;
- equip all students with basic life skills;
- promote the preservation and protection of the environment;
- develop in all students an understanding of the importance of a healthy lifestyle;
- help all students acquire the knowledge, skills and attitudes necessary to be intelligent consumers;
- provide opportunities for all students to develop an understanding and appreciation of the diversity of our culture; and
- provide opportunities for all students to develop an appreciation for beauty and human achievement in the visual and performing arts.

An analysis of the educational philosophy of the Ministry of Education's Policy Paper (1993 – 2003) and of the goals for education derived from it by the Curriculum Development Division (as outlined above), taken with the research conducted in developed nations, has led to the identification of six areas in which all secondary students must achieve. These are universally accepted goals that have been developed and underscored by other educational jurisdictions and have been described as essential learning outcomes. These outcomes help to define standards of attainment for all secondary school students.

THE ESSENTIAL LEARNING OUTCOMES

The six outcomes are in the areas of:

- Aesthetic Expression
- Citizenship
- Communication
- Personal Development
- Problem Solving
- Technological Competence

The achievement of these essential learning outcomes by all students is the goal that every core curriculum subject must facilitate. The core curriculum subjects, their content, and the teaching, learning and assessment strategies are the means to fulfil this end.

It is expected that by the end of the third year of secondary school students' achievement in all six areas will result in a solid foundation of knowledge, skills and attitudes which will constitute the base for a platform for living in the Trinidad and Tobago society and for making informed choices for further secondary education.

The essential learning outcomes are described more fully below.

Aesthetic Expression

Students should recognise that the arts represent an important facet of their development, and that they should respond positively to its various forms. They should be able to demonstrate visual acuity and aesthetic sensibilities and sensitivities in expressing themselves through the arts.

Students should be able, for example, to

- use various art forms as a means of formulating and expressing ideas, perceptions and feelings;
- demonstrate understanding of the contribution of the arts to daily life, cultural identity and diversity;
- demonstrate an understanding of the economic role of the arts in the global village society;
- demonstrate understanding of the ideas, perceptions and feelings of others as expressed in various art forms;
- demonstrate understanding of the significance of cultural resources, such as museums, theatres, galleries, and other expressions of the multi-cultural reality of society.

Citizenship

Students should be able to situate themselves in a multicultural, multiethnic environment with a clear understanding of the contribution they must make to social, cultural, economic, and environmental development in the local and global context.

Students should be able, for example, to

- demonstrate an understanding of sustainable development and its implications for the environment locally and globally;
- demonstrate an understanding of Trinidad and Tobago's political, social and economic systems in the global context;
- demonstrate understanding of the social, political and economic forces that have shaped the past and present, and apply those understandings to the process of planning for the future;
- examine issues of human rights and recognize and react against forms of discrimination, violence and anti-social behaviours;
- determine the principles and actions of a just, peaceful, pluralistic and democratic society, and act accordingly;

- demonstrate an understanding of their own cultural heritage, cultural identity and that of others and the contribution of multiculturalism to society.

Communication

Students should be able to, through the use of their bodies, language, tools, symbols and media, demonstrate their deeper understandings of synergies inherent in the exchange of ideas and information and thus communicate more effectively.

Students should be able, for example, to

- explore, reflect on, and express their own ideas, learning, perceptions and feelings;
- demonstrate understanding of facts and relationships presented through words, numbers symbols, graphs and charts;
- demonstrate sensitivity and empathy where necessary in communicating various kinds of emotions and information;
- present information and instructions clearly, logically, concisely and accurately for a variety of audiences;
- interpret and evaluate data, and express ideas in everyday language;
- critically reflect on and interpret ideas presented through a variety of media.

Personal Development

Students should be able to grow from inside out, continually enlarging their knowledge base, expanding their horizons and challenging themselves in the pursuit of a healthy and productive life.

Students should be able, for example, to:

- demonstrate preparedness for the transition to work and further learning;
- make appropriate decisions and take responsibility for those decisions;
- work and study purposefully both independently and in cooperative groups;
- demonstrate an understanding of the relationship between health and lifestyle;
- discriminate amongst a wide variety of career opportunities;
- demonstrate coping, management and interpersonal skills;
- display intellectual curiosity, an entrepreneurial spirit and initiative;
- reflect critically on ethical and other issues;
- deal effectively with change and become agents for positive, effective change.

Problem Solving

Students should know problem-solving strategies and be able to apply them to situations they encounter.

They should develop critical thinking and inquiry skills with which they can process information to solve a wide variety of problems.

Students should be able, for example, to

- acquire, process and interpret information critically to make informed decisions;
- use a variety of strategies and perspectives with flexibility and creativity for solving problems;
- formulate tentative ideas, and question their own assumptions and those of others;
- solve problems individually and collaboratively;
- identify, describe, formulate and reformulate problems;
- frame and test hypotheses;
- ask questions, observe relationships, make inferences, and draw conclusions;
- identify, describe and interpret different points of view and distinguish fact from opinion.

Technological Competence

Students should be technologically literate, able to understand and use various technologies, and demonstrate an understanding of the role of technology in their lives, in society, and the world at large.

Students should be able, for example, to

- locate, evaluate, adapt, create, and share information using a variety of sources and technologies;
- demonstrate understanding of and use existing and developing technologies appropriately;
- demonstrate an understanding of the impact of technology on society;
- demonstrate an understanding of ethical issues related to the use of technology in a local and global context.

VISION STATEMENT

The Trinidad and Tobago Mathematics curriculum will foster the growth and development of mathematically empowered students who can make an effective contribution to our society in an increasingly technological world.

RATIONALE FOR THE TEACHING AND LEARNING OF MATHEMATICS

The teaching and learning of mathematics has been under constant scrutiny over the last fifty years. Reports from external examination bodies, the Ministry of Education, employers and public and private agencies on mathematical achievement, have all concluded that the majority of our students at the primary and secondary levels lack basic skills in numeracy. The high percentage of students who are not certified as being proficient in mathematics is an indicator to the Ministry of Education that there is a problem. There are many factors that must be considered in improving this situation, but the most important will be the design of a mathematics curriculum that is relevant to the individual and to the needs of the society.

Mathematics is an activity that is intrinsic to the development of the mind, civilization and the daily lives of each individual. It is the study of the properties of number and its relation to measurement, space, shape, statistics and probability. Mathematics is essentially an abstract subject, and algebra is in essence the strand of mathematics that presents this in its purest form. The study of mathematics enables one to become a creative and critical thinker through the development of logical thinking, problem solving, and argumentative and investigative skills.

Mathematically empowered students adapt to accelerating changes in today's society because they would have acquired basic skills, self-confidence and self-reliance to be capable of making effective contributions to their society. Through practising and experiencing the mathematics processes of communication, reasoning, making connections, representations and the recognition of patterns and relationships, students would have achieved the essential learning outcomes and inevitably the goals of education. Students acquire mathematical power by constructing mathematical knowledge and understandings. The philosophy of education is underpinned by the belief that all children can learn, and that children learn in diverse ways. Therefore, the delivery of the mathematics curriculum is informed by research on an on-going basis both with regards to the nature and purpose of mathematics, as well as the pedagogy, in order to ensure that all students become mathematically proficient.

Mathematics pervades our daily lives. Therefore the mathematics curriculum reflects the various ways in which students would encounter mathematics in their environment and in real life situations. It is instrumental in developing problem solving and organizational skills. Mathematics is essential to the study of all other subjects on the curriculum. It is a core and compulsory subject on both the primary and secondary schools' curriculum and this in itself underscores its value and the role that mathematics plays in our lives.

GOALS OF THE MATHEMATICS CURRICULUM

The goals of the Mathematics curriculum were arrived at by examining the philosophy, psychology, sociology, research findings, goals and essential learning outcomes defined for the education system in Trinidad and Tobago. The philosophy states that “Education must foster moral, intellectual, spiritual, physical, social and emotional development of the child to enable him or her to live creative and productive lives” and that “ every child has a right to an education which would enhance his or her development regardless of ... background”. Part One of this document summarizes the above characteristics of the education system. Goals are desired expectations. They are statements of intent, that is, what one sets out to achieve. The goals of the Mathematics curriculum are:-

- To make mathematics relevant to the interests and experiences of the students and to prepare students for the use of mathematics in further studies
- To cultivate creativity and critical thinking in applying mathematical knowledge and concepts to solve routine and non-routine problems
- To develop skills in inquiry by the use of mathematics to explain phenomena, and by recognition of the influence of mathematics in the advancement of civilization
- To develop self-reliance, honesty, open-mindedness, confidence and perseverance by cultivating a method of studying Mathematics that results in success
- To promote appreciation of the role of mathematics in the aesthetics and to make mathematics fun
- To enable students to communicate effectively, accurately and with clarity using mathematical language and representations orally, in writing and graphically
- To encourage collaboration among students and to promote positive attitudes and values in students through the completion of mathematical tasks
- To provide opportunities for students to experience the structure of mathematics and to appreciate the elegance and power of mathematics
- To provide students with a range of knowledge, skills and techniques relating to number, geometry (space and shape), algebra, measurement, relations, functions, and statistics in a manner relevant to the technological advancements of the 21st century.

GENERAL INTENDED OUTCOMES FOR FORMS I, II AND III

Students, by the end of Form Three, will:

- use relevant mathematical programmes in accordance with their needs to prepare for the world of work, citizenship and further study
- solve routine and non-routine mathematical problems using a variety of strategies and demonstrating creative and critical thinking skills
- demonstrate skills in inquiry to investigate or examine the environment, other disciplines and the progress of mankind
- work independently and demonstrate competence in a variety of mathematical assessments
- enjoy doing mathematics and demonstrate an appreciation of the connection between mathematics, physical education and the visual and performing arts
- become effective communicators, presenting mathematical responses through discourse, in writing and graphically with the required degree of accuracy, logical sequencing and clarity
- display positive attitudes such as confidence, determination, thoroughness, respect for self and others, cooperation and teamwork
- cultivate an awareness of the nature and purpose of mathematics
- apply the mathematical knowledge and skills relating to all strands and use up-to-date technology to enhance learning.

CONNECTIONS TO OTHER CORE CURRICULUM AREAS

Mathematics is central to the secondary education core curriculum in all schools in Trinidad and Tobago. The teacher should integrate, where possible, Mathematics with other areas of the curriculum. In the process, the learner will observe how mathematics is used in daily life and be provided with opportunities to practice mathematical skills, while enhancing a better understanding of mathematical concepts. The concepts and skills developed in mathematical classrooms are applied in other disciplines.

The following briefly illustrates the nature of the connections and interdependent linkages between Mathematics and the other core areas.

LANGUAGE ARTS

- Interpreting diagrams, tables and charts
- Understanding terminology in mathematics by reading, engaging in oral discussion, debating, writing and listening
- Using the ideas of vocabulary, comprehension, analysis and inference to develop thinking skills
- Developing multiple literacy skills
- Using checklists to ensure that procedures are followed
- Formatting information for documentation

SOCIAL STUDIES

- Using statistics to analyze exponential growth of populations, rates of growth, distribution, basic demographics and traffic patterns
- Developing perceptions and skills in problem-solving and decision making in Social Studies which require a basic understanding of mathematical concepts and skills
- Using mathematical techniques for inquiry to foster understanding of the need for environmental protection, conservation and preservation
- Representing human settlements and other phenomena such as distribution, density and economic activities on diagrams, graphs, tables, charts and maps
- Recognizing that the functioning of social institutions, such as banks, insurance companies and credit unions is based on fundamental mathematics
- Influencing social interaction through an understanding of spatial arrangements

TECHNOLOGY EDUCATION

- Planning and designing in productions which require fundamental mathematics – consumer arithmetic, measurement, ratio and geometry
- Interpreting plans, drawings, blueprints, elevations, scales, and so on, which require basic geometrical and computational skills
- Programming computer software applications for information technology, which require a knowledge of the binary base system
- Infusing the use of technology in the Mathematics curriculum to develop research, investigatory and reporting skills.

SPANISH

- Using numbers to record information such as age, date of birth and other personal data
- Developing vocabulary using terminology from the measurement strand in Mathematics
- Counting and recording quantities such as number of family members and population of countries.

SCIENCE

- Quantifying natural and artificial phenomena such as earthquakes, volcanic activity, temperature, speed, viscosity, spatial distribution, projectile motion, patterns, cell division and growth
- Investigating issues in science which require the use of basic mathematical principles and skills

- Collecting and representing scientific data which depend on skills in measurement, statistics, relations and functions

VISUAL AND PERFORMING ARTS

- Understanding timing and sound in music, which are based on basic mathematical concepts in number and trigonometry
- Observing the beauty in art and nature, which is based on the concept of symmetry in geometry
- Drawing, designing and dancing, which are dependent on acquiring skills in geometry and fundamental mathematics
- Producing art and craft which require the use of calculations, spatial sense and fundamental concepts in mathematics
- Sequencing of dance steps and patterns in dance, which are dependent on geometrical and number concepts and skills

HEALTH AND PHYSICAL EDUCATION

- Classifying foods into the six food groups and quantifying the number of calories or nutrients present in foods
- Comparing individuals' weight and height with the ideal weight and height dependent on age and physical stature
- Discussing obesity and malnutrition in the context of inequalities in mathematics
- Valuing water and air as important constituents of the body by quantifying the essential amounts required
- Counting to maintain rhythm in exercises, aerobics and gymnastics
- Designing and following a plan for aerobic exercises requiring a knowledge of spatial sense, shape and rhythm
- Using diagrams and graphs to display information
- Using problem-solving skills to cope with stress and acquire adequate rest and relaxation
- Playing games by following rules and using strategies
- Appreciating exercise and its effect on the aesthetics of the body
- Appreciating sports and the wise use of leisure which can be displayed on a pie chart
- Monitoring energy levels, respiratory demands, blood pressure, elimination, musculature and mental health, using the appropriate instruments
- Using a statistical approach to test physical fitness

VALUES EDUCATION

- Infusing values into the Mathematics curriculum by encouraging a display of positive values such as collaboration, teamwork, respect for others, determination, thoroughness and confidence
- Fostering sharing and caring for others and unequal sharing of quantities into the topic "Ratio and Proportion"
- Teaching different types of relationships of social interaction and the impact of these on life through infusion into the topic "Relation and Functions"
- Teaching budgeting, consumerism and fair business practices through the topic of "Consumer Arithmetic"
- Using Venn diagrams in the topic "Sets" to represent religions, ethnic groupings and interests, to develop an understanding of the diversity of the society
- Fostering various types of social interaction by using different seating arrangements