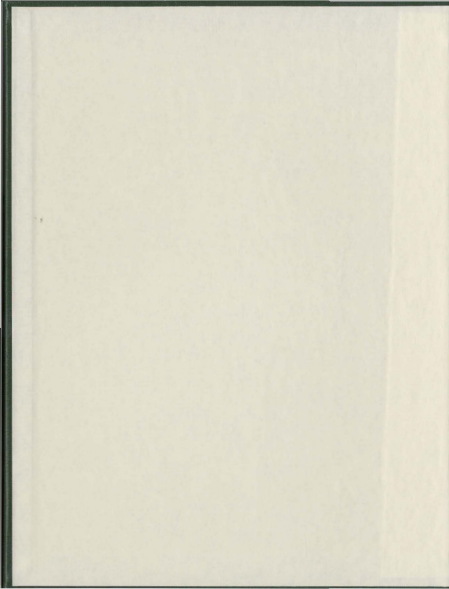


TEACHERS' ATTITUDES TOWARD AND PERCEPTIONS
OF MATHEMATICS REFORM IN NEWFOUNDLAND:
A QUALITATIVE RESEARCH STUDY

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Teachers' Attitudes Toward
and
Perceptions of
Mathematics Reform
in
Newfoundland:
A Qualitative Research Study

by

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ABSTRACT

Math reform in schools has been the subject of considerable debate for decades. The National Council of Teachers of Mathematics (NCTM) defines the reform's goal as to promote a paradigm shift away from traditional approaches involving rote memorization and skill training (drill) toward problem-solving, reasoning and communication as the basis of deeper conceptual understanding. Despite significant efforts in reform implementation, a tension between the old and new approaches still exists and presents an important issue for mathematics educators.

This thesis documents narratives of eight mathematics teachers selected from the Eastern School District of St. John's, Newfoundland about how they deal with mathematics reform and what are their accomplishments, shortages and needs. It presents an interpretive qualitative study using in-depth interviews and the constant comparison method of data analysis.

This study reveals that teachers have a good understanding of the key ideas underlying reform but many still feel uncomfortable and somewhat disarmed when facing numerous challenges and lack of support which might force them to return to traditional practices. The implications of this study for the education system are discussed.

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DEDICATION

This thesis is dedicated to my uncle, **Frederick George Manuel**, who passed away during the midpoint of my graduate program. He spent years encouraging me to pursue a Master of Education degree and always felt that my interest in math reform should be explored. He would be proud.

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CHAPTER ONE

INTRODUCTION

This inquiry focuses upon the major mathematics reform effort and aspects of its impact on teachers. After describing the key ideas underlying reform, I address the issue of why mathematics teachers have struggled with reform and often return to traditional practice. For numerous reasons, they have been uneasy about the new paradigm proposed by reform. Conflicting views on mathematical pedagogy have persisted, a state of affairs which suggests that mathematics as a field of knowledge to be taught to students may be in a state of crisis (Lockhart, 2002 and Shoenfield, 1998). In order to be resolved, this controversial situation calls for action. Research into understanding the teachers' perspective will inform the process of decision making regarding the debate over math reform.

1.1 Background/Overview

Qualitative research has as its primary goal the description and understanding of a phenomenon, process, a culture or the perspectives and world-views of the people or group under study (Merriam, 2002). I will investigate teachers' perceptions and attitudes toward delivering the mathematics curriculum, particularly in the context of changes brought about by

reformist efforts. Widespread reform in mathematics education in North America was spearheaded by the National Council of Teachers of Mathematics (NCTM) in 1989. That year the NCTM published *Curriculum and Evaluation Standards for School Mathematics*, (1989) which addressed various aspects of mathematical pedagogy. These led to the production of similar documents in many jurisdictions including those from Canadian provincial Departments of Education and organizations such as the Atlantic Evaluation and Research Consultants (ACER). The overriding goal was to reform mathematics teaching by moving it away from traditional approaches and toward a new investigative paradigm. Mathematics teachers were expected to teach in accordance with the tenets of the new philosophy and to effect changes in their teaching styles/models. *NCTM Principles and Standards for School Mathematics* (2000) describe the intended state of affairs as follows:

The curriculum is mathematically rich, offering students opportunities to learn important mathematical concepts and procedures with understanding. Technology is an essential component of the environment. Students confidently engage in complex mathematical tasks chosen carefully by teachers. They draw on knowledge from a wide variety of mathematical topics, sometimes approaching the same

problem from different mathematical perspectives or representing the mathematics in different ways until they find methods that enable them to make progress. Teachers help students to make, refine, and explore conjectures on the basis of evidence and use a variety of reasoning and proof techniques to confirm or disprove those conjectures. Students are flexible and resourceful problem solvers. Alone or in groups and with access to technology, they work productively and reflectively, with the skilled guidance of their teachers. Orally and in writing, students communicate their ideas and results effectively. They value mathematics and engage actively in learning it. (p. 5)

I became interested in the topic after conducting preliminary formal research, specifically about the "Math Wars," in the context of the major reform effort referred to above. I began to reflect on the debates and concepts in the literature as well as on my own experience in teaching mathematics and to scrutinize the demands and expectations stemming from the reform philosophy. On a more informal note, over the years I have conversed with other mathematics teachers about their attitudes and perceptions arising from

individual experience in the classroom. These reflections stimulated my interests in the math reform.

1. 2 Statement of the Problem

"Research focused on discovery, insight, and understanding from the perspectives of those being studied offers the greatest promise of making significant contributions to the knowledge base and practice of education" (Merriam, 2002, p. 1). My research concerns how the vision of the NCTM reform impacts on teachers and their perceptions, attitudes and practices. The research problem is to collect knowledge about mathematics teachers' responses to the NCTM reform in the province of Newfoundland and Labrador. This research study should be conducted because it is teachers who are required to enact the new curriculum, so that the realization or failure of the vision will largely depend on teachers. For Marshall and Rossman (1999), the key elements of the value/viability of a research proposal are to demonstrate that a given piece of research "should, can, and will be done" (p. 54). My research should be done because we need more knowledge of teachers' perspectives on reformist mathematics (many would claim urgently so). It could be done because I proposed a methodology and data collection plan which was focused, logical and manageable. The research was done by thoroughly reviewing the

literature to contribute to triangulation and validity, by conducting in-depth interviews with mathematics teachers, presenting and analyzing the data in a coherent manner, and by providing a list of scholarly references.

1.3 Purpose/Significance of the Problem

A key purpose is to investigate what one might call an “unknown.”

There may be an important gap in our knowledge regarding the translation of theory (reformist concepts) into practice (actual mathematics teaching).

Research may reveal that the viewpoints of teachers who are at the centre stage of pedagogy (and who are thus the ultimate agents of educational implementation) might differ from those of educational theorists, government officials and other influential stakeholders. A focus on teachers’ views will help to illuminate a possible neglected area of research. A preliminary review of the literature indicates that much attention has been devoted either to characterizing the reformist approach and describing how it differs from traditional orientations, or to examining how students perform and achieve in reference to the two models (Boaler, 2002). We need more knowledge about teachers’ responses to reform, given that they are at the heart of educational change and have to make it work. Similar to Grant, Peterson and Shojgreen-

Downer (1996), I ask the questions: What are teachers' responses to the mathematics education reform? Why do teachers respond the way they do? Such knowledge might yield insights about the roles of educational stakeholders in general and how these differ from those of teachers.

1.4 Research Questions

The following research questions are investigated in this qualitative study. I seek to understand and describe participants' constructions of meanings for their experiences, situations, and activities.

1. How have mathematics teachers adapted to changes in the curriculum?

Have they modified their practice?

2. What kinds of obstacles do teachers perceive in meeting reform expectations? To what extent do they feel supported in implementing the goals of reform?
3. Do teachers feel qualified and confident in enacting reformist goals in terms of the subject matter (mathematics) and pedagogical competence? Are teachers lacking in mathematical knowledge or classroom management skills, or both with regard to the implementation of the new reform philosophy?

4. What are teachers' attitudes toward opportunities for professional development? Do they feel they have enough assistance in teaching according to a new approach? Do they believe they need more explicit and helpful guidance in meeting reform goals?

Cohen, Manion, and Morrison (2007) state that it is vital to operationalize research questions by moving from the abstract to the concrete. The researcher "breaks down each general research purpose or general aim into more specific research purposes and constituent elements" (p. 81). Yet qualitative inquiry, especially in its earliest stages, does not demand too great a concreteness or specificity either. As Tite (2002) points out, qualitative researchers "are open to an emergent design, meaning that they are often unwilling to specify their questions too concretely and are more likely than quantitative researchers to modify, reformulate and redirect their questions as they go along" (p. 5). Some of the topic-oriented studies in the literature assisted me in modifying and articulating the four research questions listed above, and to generate more specific questions to guide the interview process.

CHAPTER TWO

LITERATURE REVIEW

2.1 Topic-Oriented Literature

A preliminary review of topic-oriented studies reveals several highly insightful pieces of research. Many of them indicate that the process of teachers' adaptation to the reform is not easy and requires understanding of the obstacles the teachers encounter. Heaton (2000) not only provides one of the most useful characterizations of the differences between the traditional and the reform models but also describes her experiences in adjusting to a reformist curriculum. In a study of eighth grade teachers and their schools, Sosniak, Ethington and Varelas (1994) found that teachers are frequently frustrated with reform because schools and classrooms are structurally designed to support and promote traditional views and practices. Ball (1994) analyzes the difficulties and uncertainties of applying reform principles to the classroom. In a qualitative study of six middle and high school math teachers who attempted to implement the reform curriculum, Orrill and Anthony (2003) identify aspects of how teachers perceive and struggle with the new mathematical pedagogy. Boaler (2002) suggests that mathematics teachers are especially cautious and

conservative and that this outlook prevents them from embracing reform. The final report by the Atlantic Evaluation and Research Consultants entitled *K-12 Mathematics Curriculum Review* commissioned by the Department of Education of Newfoundland and Labrador (November, 2007) provides comprehensive insights and recommendations regarding the adequacy of the mathematics curriculum in the province of Newfoundland and Labrador including the proposal to adopt the Western and Northern Canadian Protocol (WNCP) Curriculum Frameworks.

2. 1. 1 What is Reform?

The overriding goal from the NCTM (1989) was to reform mathematics teaching by moving it away from traditional approaches and toward a new investigative paradigm. Broad political and cultural factors played an important role. Politicians, the business community, and other educational stakeholders, fearful that America was losing its competitive edge as an advanced capitalist nation, focused on improvement of mathematics teaching at all levels (Hirsch, 2001). At a more local level, state and district officials were dissatisfied with student performance on tests and other means of assessment. All thought that change was needed.

Hirsch (2001) frames the intellectual roots of the "Education Wars" in terms of the historic difference between the classical/traditional orientation to education and the romantic/progressive approach. The former emphasizes the repetitive practice of mathematics algorithms, rote learning, maximum time spent on learning tasks, objective testing and explicit academic goals, whereas the latter holds that "real world applications of mathematics provides a truer understanding of math than empty mastery of formal relationships" (p. 19). According to the NCTM 2000 document (as cited in Olivera, 2005), standards based reform in mathematics involves five major shifts in classroom instruction:

Reform teachers (a) view classrooms as mathematical communities rather than collections of individuals; (b) use logic and mathematical evidence to verify results rather than relying on the teacher as the authority; (c) emphasize mathematical reasoning rather than memorizing procedures; (d) focus on conjecture, inventing, and problem solving rather than mechanical answer finding; and (e) make connections among the ideas and applications of mathematics rather than seeing them as isolated concepts and procedures. (p. 494)

Burrill (2001) notes that the documents produced by the NCTM call for a “shift in content from learning only skills and procedures to being able to use mathematical knowledge to solve problems, a shift in teaching from disseminating information to enabling students to learn using student thinking as the platform” (p. 28). Canada (2007) observes:

While the content of Reform Mathematics may differ in emphasis from that of traditional curriculum, it is in the method of teaching that this movement draws the most distinction. Advocating real-life applications and problem solving, Reform Mathematics curriculum encourages students to reason and communicate mathematically. (p. 6)

The notion of more active student engagement is promoted by Shouse (2001) who observes that, in reformist thinking, mathematics students:

are more likely to develop understanding when their teachers present problems that allow them to discover or construct knowledge for themselves. Put more simply, one might say that traditionalists offer tools with which students can solve problems; reformers offer problems that prompt students to develop tools. (p. 115)

Clearly, reform calls for a new philosophy of education and a redefinition of the roles of student and teacher.

One of the most useful characterizations of the differences between the traditional and the reform models is provided by Heaton (2000). She contrasts the models in terms of straightforward dichotomies which can be summarized as follows based on the table she presents in *Teaching Mathematics to the New Standard*: (Adapted from Heaton, pp. 6-7, 144).

<u>Old (traditional model)</u>	<u>New (reformist approach)</u>
<ul style="list-style-type: none"> ▪ rote practice, memorization ▪ emphasis on mechanical answer-finding ▪ mathematics as a body of isolated concepts and procedures ▪ teachers as experts "tell" ▪ teachers follow a prescribed curriculum ▪ classroom as collections of individuals ▪ students work alone to do math 	<ul style="list-style-type: none"> ▪ mathematical reasoning ▪ conjecturing, inventing and problem solving ▪ connecting mathematics, its ideas and its applications ▪ teachers do not "tell" directly but lead and overview the learning process ▪ a more flexible prescribed curriculum ▪ classrooms as mathematical communities ▪ students are given both individual and group assignments

Such dichotomies may be somewhat simplistic but they do help clarify basic principles.

However, according to the traditionalist Andrews (1996), the language could be worded differently. He provides the following table which illustrates conflict and mutual disagreement between the two camps: (Adapted from Andrews, pp. 346-347).

<u>Old (traditional model)</u>	<u>New (reformist approach)</u>
<ul style="list-style-type: none"> ▪ Focused homework ▪ Essential drill ▪ Problems designed to reinforce a clearly designated concept ▪ Appropriate memorization ▪ Drills fostering familiarity with necessary skills ▪ Focused exercises ▪ Focused topics ▪ Clear elucidation of each mathematical method ▪ Carefully prepared, objective tests ▪ Focused problems ▪ Clearly written answers to each problem ▪ Focused lectures 	<ul style="list-style-type: none"> ▪ Chaotic self-instruction ▪ Thoughtless, pervasive use of calculators ▪ Artificially contrived, multi-step fiascoes ▪ Pretense that mathematical reasoning can precede mathematical facility ▪ Pretense that conceptual understanding can precede mathematical facility ▪ Contrived "realistic problems" supposedly encountered by adults ▪ Mishmash of topics precluding conceptual organization ▪ Mishmash of problem solving techniques ▪ Variety of so-called "assessment instruments," each likely to hide the students' truly poor level of achievement ▪ Problems so poorly posed that each possible answer is debatable ▪ Allowing the student to explain away ignorance ▪ A phantasmagoria of so-called "teaching" so-called "strategies"

This table illustrates how the reformists' ideas, even progressively intended, may be perceived by a practicing teacher, whose own education and work experience significantly differ from the new teaching approach and who is confronted with everyday schooling reality. It is obvious that such a teacher will need to be convinced and supported in many ways before they start to understand the benefits and advantages of the new teaching methodology.

Reformist mathematical pedagogy requires educators to move beyond assumptions of the traditional approach. As Ernest (1994) states, it abandons the thesis that mathematical knowledge is founded on a fixed basis of truth that is established without human agency. According to Schoenfeld (1988), students in a traditional setting, "view themselves as passive consumers of others' mathematics," so that there is "little sense of exploration or of the possibility that the students could make sense of the mathematics for themselves" (pp. 14-15). The reform documents propose broad changes that would have mathematics teachers embrace a new paradigm.

A difference between traditional and reformist orientations may be illustrated by considering an example from geometry – the formula for the calculation of the area of a triangle ($A = \frac{1}{2}bh$). Traditionally the teacher provides this formula to students who are expected to memorize it and apply it in exercises. Reformers take a different approach, apparently one more in line with Japanese methods. Using evidence from a videotaped study of fifth-grade classrooms comparing Japanese and American lessons in geometry, Gamoran (2001) discusses how the two differ with regard to the problem of finding the area of a triangle. He observed:

A typical American lesson unfolds as follows: there is a bit of review of previous concepts, which may or may not relate to the topic of the day; the teacher explains the concept of base times height divided by two, and demonstrates a few problems and then students spend substantial time practicing problems using this formula. In Japan the lesson unfolds differently: first the teacher presents the problem; students then attempt to solve the problem on their own; next there is a class discussion of solutions the students derived, leading to the general formula; and finally, students work on problems on their own. (p. 139)

Gamoran also points out that one of the important political/cultural motivations for reform in North America was the contention that Japanese students outperform their American counterparts in mathematics. D'Ambrosia (2004, as cited in Lookabill 2008) explains that the main recommendation of the NCTM is the development of conceptual understanding of mathematics through an inquiry approach to teaching and learning that influences students' meaningful learning of mathematics. Ball (1994) points out, however, that the NCTM Standards can "sketch directions and commitments, principles and aspirations" but they cannot "provide guidance for the specifics of minute-to-minute practice or for the decisions met day to day" (p. 5). Indeed, the path

from the formulation of reformist concepts to their actual implementation in the classroom is a complex and troubled one. Orrill and Anthony (2003) state:

Attempts to implement school-based innovations often falter because teachers' prior beliefs about teaching and learning remain largely unchanged and intact. As a result, teachers fail to commit to the innovation, returning to their original teaching habits once they are able to. (p. 1)

This suggests, among other things, that either reform supporters do not fully consider teacher practice and attitudes or that, for some reason, teachers have been resistant to change. Battista (2001) concludes that while most mathematics teachers claim they understand the NCTM philosophy, traditional mathematics is still the norm in most schools and "the majority still adheres to teaching that is traditional at its core" (p. 76). Why might this be so? I will now examine some implications of reformist principles for teachers who are asked to enact them.

2. 1. 2 Why Have Teachers Struggled With Reform?

In educational literature there has been a growing concern that mathematics teachers have been unhappy with applying reformist concepts.

Howe (2000) claims that "a superb curriculum is beside the point if it makes demands that a teacher cannot meet" (p. 1076). For one thing, teachers must redefine their role. Having students engage in discussion and work in groups can make teachers feel insecure because they "are no longer seen to be in the seat of authority" (Gibbs and Orton, 1994, p. 110). In a reform-oriented classroom teachers experience what Frobisher (1994) calls a "loosening of the reins of control" and find it difficult to resist the urge to "tell" (p. 165). To aggravate matters, teachers, particularly in the United States, resent that they have not had their voice fully heard regarding curriculum change. Howson, Keitel, and Kilpatrick (1981) observed about a decade before the mathematics reform, that teachers have been usually "treated more like guinea-pigs than partners" (p. 63), and they add that many curriculum developers often "produce materials that bypass the teacher, reducing his/her role to that of monitor or clerk" (p. 54). It is clear that successful reform implementation should involve teacher input because, as Cooney, Sanchez, and Ice (2001) remind us, teachers are the agents of change in the classroom.

Aspects of school culture may prevent mathematics teachers from embracing reform. A study of 143 eighth grade teachers and their schools found that "structurally and functionally", schools and classrooms "are

designed to support and promote the continued transmission of traditional views and practices" (Sosniak, Ethington, and Varelas, 1994, p. 110). Howson, Keitel, and Kilpatrick (1981) argue that school cultures are resistant to change, especially when it is introduced from outside and they add that when teachers do seek change, they are limited by administrative structures. Orrill and Anthony (2003) identify numerous aspects of how teachers struggle with the new mathematical pedagogy, leading to reduced teacher confidence to teach in a new way. In their opinion, the changing beliefs and roles require teachers to change longstanding assumptions, leading to uncertainty and confusion. They identify the negative impact of structural constraints in school cultures like problems with support and divisiveness in math departments, and with school administrations. Teachers lack experience with and knowledge of new curriculum materials and often think that the professional development sessions they engage in are inadequate. They report that teachers raise issues about the lack of grades, delays in testing, and difficulties in determining what students learn, and that teachers have limited experience in using group approaches and strategies. Finally, they state teachers feel that parents do not respond positively to the new curriculum.

Let us consider briefly teacher preparation programs as to their perceived effectiveness. In referring to curriculum innovations about a half century ago in a British context, Roper and Carter (1994) stress the importance of teachers' understanding of the philosophy of reform and their mastery of the materials to be used. Burrill (2001) concludes that many teachers "have not been prepared to implement change" and that they "do not usually have the long-term support that is essential to figuring out what they should be doing differently" (p. 37). Davis (1995) argues that teacher preparation programs "do little to prepare teachers to teach differently than they were taught" (p. 8). In a qualitative study of six middle and high school mathematics teachers who attempted to implement the reform mathematics curriculum, Orrill and Anthony (2003) found that teachers believed the professional development they received was inadequate. Finally, Cheeseman (2007) notes a lack of enthusiasm among teachers taking the "mathematical journey" to accommodate reform, remaining more traditional in their teaching approach.

Professional assistance remains problematic. A very recent study based on twelve different CETP projects (Collaborations for Excellence in Teacher Preparation) conducted by Huffman, Thomas, and Lawrenz (2008), found that teachers participating in the programs mostly did not adopt reform-oriented

practices (such as having students work in groups and generating discussion) and that traditional teaching methods prevailed. Although teachers have reported that the service training increases their understanding of reform principles and raises their confidence to teach mathematics, the overall effect remains unclear (Kirtman, 2008).

Referring to the claim that most teachers are “essentially cautious and conservative” Boaler (1992) suggests that “various forms of evidence indicate that this description can be more accurately applied to teachers of mathematics than any other subject group” (p. 184-185), but does not specify and describe the evidence which might support her assertion. In contrast to that statement, one may suggest that macro forces such as school culture constraints and broad cultural factors may be more important than micro forces such as teacher and students’ characteristics. For instance, Lockhart (2002) asserts that the blame for reform failure deserves a wide distribution:

No, I blame the culture that produces them. The poor devils are trying their best, and only doing what they’ve been trained to do ... They can sense that they have been made cogs in a great soul-crushing machine, but they lack the perspective needed to understand it, or to fight against it. (p. 17)

2. 1. 3 Further Aspects Influencing Teachers' Attitude Towards the Reform

The Math Wars (Becker and Jacob, 1998) have continued for at least fifty years and there are few signs of compromise. The literature is populated with military metaphors – struggles, skirmishes, disasters, counteroffensives, backlash. Backlashes against reform are common. For example, in Texas, Governor Ross Perot, who later ran for President of the United States as an independent candidate, sought a return to traditional methods which included back-to-basics and an increase in standardized testing (McNeil, 2004). In California, a counter-reform movement emerged which opposed the NCTM Standards and the California Mathematics Framework (Becker and Jacob, 1998).

Is there a black hole at the heart of mathematical pedagogy in the sense that we do not know what mathematics as a field of knowledge to be taught to students really is or should be? Gadanidis and Hoogland (2002) view mathematics as “an aesthetic and storied experience” (p. 7). As aesthetics, it appeals to people’s notion of beauty, their emotional and imaginative life, their sense of wonder. As story, mathematics can provide scripts which improve self-understanding and understanding of the world. The problematic nature of what mathematics is as a field is articulated by Lockhart (2002) in a spirited

critique. For him, mathematics is an art and there is “nothing as dreamy and poetic, nothing as radical, subversive, and psychedelic as mathematics” (p. 6). He suggests that there is a fundamental crisis in mathematical pedagogy when he states that “we as a culture don’t know what mathematics is” (p. 8). He maintains that “school boards do not understand what math is, neither do educators, text book authors, publishing companies, and sadly neither do most of our math teachers” (p. 8).

For Lockhart (2002) the crisis in mathematical education is a broad cultural one. Schoenfeld (1988) would concur and he uses the term “disaster” to describe the teaching of mathematics, which indicates that he too believes that the field may be in a crisis. He gives an arithmetic example in which army buses (each with 36 seats) must transport 1128 soldiers. The question is: How many are needed? About a third of his students answered that the number was “31 remainder 12.” This reply, he claims, demonstrates that “something has gone very, very wrong” (p. 16).

Ten years ago U.S. Secretary of Education Richard Riley addressed the Mathematical Association of America and spoke of the need to “bring an end to the shortsighted, politicized and harmful bickering over the teaching and learning of mathematics” (cited in Becker and Jacob, 1998). Yet there is no

sign that the controversy about the two paradigms will subside. Reform will continue to face challenges. As Ball (1994) once observed, reforming mathematics is “no short order” because it requires “profound and extensive societal and individual learning – and unlearning” (p. 4). Overwhelmed by the magnitude of the issue, Saul (2000) concludes skeptically that “we are not ready for the Definitive Document in education, and it is not clear that such a document is even possible” (p. 1079).

2.2 Genre-Oriented Literature

Along with topic-related literature, genre-oriented literature has been very instructive and useful. Cohen, Manion and Morrison (2007) provide clear descriptions of qualitative research; their coverage of the interview process and qualitative data analysis have helped me formulate my thesis. Eisner (1998) has been invaluable in educating me about the power of qualitative research and the rich patterns of experiences that can be unveiled.

Finney (2000) uses a phenomenological perspective to analyze the meaning of success for students who have taken statistics courses. She is not concerned with quantitative measures of success such as grade, but rather how different individuals perceive success in various contexts. Similarly, I am not

interested in quantifying aspects of mathematics reform. Instead, I focus on how teachers in the Eastern School District of Newfoundland perceive reform – what it means to them as individual practitioners. Silva (2000) investigates the lives of teachers in a particular context (the professional development school) and provides a detailed description of the “ethos” of that context. I would like, among other things, to describe the themes and issues that pertain to the teacher ethos regarding reform. Larson (1997) examines teachers’ perceptions of discussion in classrooms and the forces that impact on their work. Gates (2000) and Gatz and Hirt (2000) deal with the meaning constructs by faculty members and students in particular contexts. Inspired by this work, I would like to describe the process of meaning construction by teachers affected by the mathematics reform.

CHAPTER THREE

METHODOLOGY

3.1 An Overview of the Methodological Approach

The purpose of this research is to determine the attitudes and perceptions of Newfoundland teachers toward math reform. As previously mentioned, this study is qualitative in nature since its goal is to describe how teachers are significantly impacted by aspects of mathematics reform. This study does not use quantitative measures but focuses on how teachers perceive math reform and what it means to them in the delivery of the mathematics curriculum in Newfoundland schools.

Using the qualitative approach to research teacher attitudes and perceptions toward math reform involves more than just collecting data. There needs to be an analysis which is based on the subjective understanding and experiences of the participants. "Learning how individuals experience and interact with their social world, the meaning it has for them, is considered an interpretive qualitative approach" (Merriam, 2002, p. 4). My research grows "out of questions researchers ask about people in specific contexts" (Hutchinson 1988, p. 125). These questions develop into patterns of experience which, when analyzed can provide a valuable perspective. A "constant

comparison of properties and dimensions enables the researcher to develop richer concepts and models of how the particular phenomenon being studied really works" (Younghusband 2005, p. 68). This work presents an interpretive qualitative study using in-depth interviews and the constant comparison method of analysis.

3.2 Population and Sample Selection

Miles and Huberman (1994) observe that qualitative researchers work with "small samples of people, nested in their context and studies in-depth" (p. 27). In this interpretive study, I utilized a sample of eight mathematics teachers who teach in elementary, junior high, and high school settings. The schools are located in the Eastern School District of Newfoundland. I did not intend to have the demographic makeup of teachers (age, gender, ethnicity and so on) become thematic. The most important criterion in sample selection is a teacher who has been significantly impacted by aspects of reformist mathematics, which means that he/she has probably been teaching mathematics for at least two or three years. Similar to Larson (2000), I initially interviewed several teachers from the sample, analyzed the data, and then interviewed the remaining subjects.

In this study a wide cross-section of teachers was targeted. Representation from each of the primary/elementary, junior high and high school levels was sought. Twenty-one teachers responded to an advertisement placed on the math forum of the First Class communication network of the Eastern School District, requesting more information on the study and indicating their willingness to volunteer. After receiving the responses, I made contact with the possible participants.

During the selection process, every attempt was made to select teachers with a varied amount of experience, with representation of both rural and urban regions. In the final selections, no consideration was given to the teacher's gender. It is believed a purposive sample is included in that it selects a particular group with no major attempt to generalize to the wider teaching population. Purposive sampling includes sites, events and participants who are self-identifying and self-selecting but are then chosen by the researcher to be studied, based on the purpose of the research and the phenomenon to be explored (Capuzzi and Gross, 2001).

Saturation became apparent after six interviews were completed. Nevertheless, another two interviews were conducted to look for more

information, ending with a total of eight participants. The eight interviews consisted of three teachers at the primary/elementary, one teacher who was strictly junior high, three teachers at the high school level and one teacher teaching junior and high school. These participants ranged in age from 24 – 51 years and experience from three years to 31 years with an average of 14 years teaching. Two of the participants taught five years or less, five had between 11 and 21 years teaching, and one teacher had 31 years of experience and was near retirement. Although gender was not an issue explored in this study, five of the teachers were female and three were male. Also, the sample was equally divided among rural and urban regions. With regard to education, four of the teachers interviewed had mathematics degrees while four did not. However, all participants had some mathematical background. Two elementary and one high school teacher had their Master of Education degree with a focus on mathematics either completed or near completion, and it was because of this involvement that they were very eager to participate in this qualitative research study. One teacher gave the following reason for why he volunteered to do an interview:

We need to decide which approach we want to go with. Right now, there is a state of confusion and teachers just don't know where to go. This flipping back and forth sends us back to square one every time. The graduate courses I've done have really opened my eyes.

3.3 Ethics

The Interdisciplinary Committee on Ethics in Human Research (ICEHR) and the education personnel at the Eastern School District (ESD) of Newfoundland gave their approval for this study to be conducted. All those interviewed were informed that participation in this study was entirely voluntary and that they were free to withdraw from the study at any time. Also, they were informed that participation was independent of their employment, and that a decision not to participate or to withdraw from the study would in no way affect their employment.

At the beginning of each interview, a discussion was held about the importance of free and informed consent. All participants in this study were provided with a description of the research and what their anticipated role in the project would be. Then each participant was provided with a copy of a letter of consent for them to complete before participating in the research (see

Appendices). This letter of consent described the purpose of the study, possible risks, possible benefits, a confidentiality and anonymity statement, a section regarding participant questions, and a statement that this study had been approved by ICEHR and found to be in compliance with Memorial University's Ethics Policy.

Informed consent and protection of subjects from harm are two dominating issues in the guidelines of ethics in research with human subjects (Bogdan & Biklen 1992, pp. 49-55). The importance of confidentiality and anonymity was conveyed as being vital. It was stressed to each participant that only my university supervisor, the transcriber and myself would have access to the tape-recording and transcriptions of the interviews. Also, it was made clear that I would be the only person to know that a specific individual was an actual participant. Finally, informed consent was obtained from all participants via their signatures on the consent form (see Appendices).

As a result, interviews were labeled by number only. Any information that might potentially identify a participant was omitted during the transcription process. All other pertinent information was kept in a secure location known only to me. It was relayed to each participant that this information would eventually be destroyed.

3.4 Data Collection Procedure

The data collection procedure began with an advertisement on the ESD's website – more specifically, the math forum on the First Class communication network (see Appendices). This advertisement gave a brief description of my study, emphasized confidentiality and invited mathematics teachers from the ESD who were willing to participate in the study to make contact with me. From this advertisement, I received more than enough respondents requesting more information about the study.

The most important criteria in sample selection was that a teacher had to be significantly impacted by aspects of reformist mathematics, which means that he/she had to have been teaching for at least three years. I made contact with potential participants via telephone or e-mail and arranged face-to-face interviews. Each interview was scheduled at a time and place that was mutually agreed upon as being convenient for the participants. Of the eight interviews conducted, two occurred in my home, three in the home of the participant, two at Memorial University of Newfoundland (MUN) campus and one at the participant's school.

Each interview required approximately one hour to complete. I recorded the interview via audio tape and made notes (with the teacher's permission)

during and immediately following the interview as reminders of items of significance.

3.5 Interviewing Process

Before receiving approval from the ESD to conduct this research study, a list of teacher interview protocols (see Appendices) had to be submitted. Over the course of three to four months I had been designing specific questions to ask in the interview, based on the key subject areas arising from the literature and research as well as my own experience as a mathematics teacher. These protocols developed into the following seven headings:

- Background
- Classroom management
- Reform
- Teacher support
- Stakeholders
- Evaluation
- Conclusions

The intention was to get the participants thinking about specific topics rather than go jumping back and forth between topics. To establish a feeling of relaxation, the interview began with some background questions dealing with experience, training, grade level and career pathway. It then moved into the more cognitive areas where I asked more probing and open-ended questions,

asking for specific examples whenever possible. Many questions started with "Do you feel?" or "Do you think?" to get the participants to go wherever they wanted or to let them reveal their true feelings in other words. To conclude, I asked more general type questions and whether there was anything else on their minds that I may have forgotten to consider. However, all participants felt that "they were pretty much talked out" after one hour.

To prepare for the interview process, I first tape-recorded myself asking the questions and playing them back. This was done to get used to the operation of the tape-recorder and to get a good familiarization with the teacher protocols. Next, I interviewed a couple of teachers who were not to be considered a part of the research study in order to gain valuable feedback with regard to length of interview, how to get participants to elaborate on questions, how to encourage teachers and make them feel important. It is significant for the researcher to convey to each participant that he or she "has had an experience worth talking about, and has an opinion of interest to the researcher. This stance will go a long way in making the respondent comfortable and forthcoming with what he or she has to offer" (Merriam 1998, p. 84).

Each interview was conducted according to plan. A prearranged time and place was set. Most of the participants requested teacher interview

protocols beforehand while two preferred not to see these protocols. Those who did believed they were better prepared. Those who did not request the interview protocols did so because they felt spontaneity was important. Nevertheless, as the number of interviews increased, I became more comfortable and felt more adequate in getting the participants to be more relaxed, and I believe this yielded better information. Additional security of the participant's openness was ensured by the fact that each participant clearly understood that they could withdraw at any time during the interview.

3. 5. 1 Researcher's Role in the Interviewing Process

Merriam (2002) explains that, "for most educators, doing research means designing a study that addresses some problem arising from practice, collecting and analyzing data relevant to the problem, and finally, interpreting the results" (p. 220). This constant comparative analysis is based on the conducting of interviews with mathematics teachers and is supplemented by detailed field notes, document analysis, especially of pertinent government publications and literature review. Interviewing is not a straightforward matter. I agree with Cohen, Manion, and Morrison (2007) that an interview may be regarded as a "transaction which inevitably has bias that needs to be reorganized and

controlled" rather than as a "pure information transfer" (pp. 349 – 350).

Research interests and biases reflect autobiographical issues and I bring my subjectivity to the research process.

As a mathematics teacher it is important that I place in abeyance my own assumptions and biases. At times I have been skeptical about efforts to reform mathematical pedagogy, in part because reformers do not seem to have consulted teachers sufficiently in proposing curriculum change. I also believe that they have not fully considered various kinds of constraints (for example, those in school culture) which make reform implementation difficult. It is crucial that I did not inject my view into the interview process and the overall research planning since it would contaminate data obtained from the study participants.

Hutchinson (1988) states that "only by being aware of his own 'mind-set' and bracketing his own values can the researcher begin to search out and understand the world of others" (p. 130). Seidman (1991) claims that the interviewer must keep "enough distance to allow the participant to fashion his or her responses as independently as possible" (p. 73) and he adds that an intrusive interviewer who looks for "corroboration of personal views rather than the story of the participant's experience – is not being fair to the purpose of in-

depth interviewing" (p. 84). Researcher intrusion interferes with the subjects' articulation of the meanings and values they have constructed.

On the other hand, if properly controlled, the biases stemming from my background as a mathematics teacher and my experiences can enhance my researcher role. As Eisner (1998) puts it, the "positive exploitation" of researcher subjectivity should be pursued and doesn't necessarily represent "a conceptual liability in understanding" (p. 34). The literature supports this view. For example, Finney (2000) uses her experience with taking statistics courses to enrich her study of students' perceptions and attitudes toward these courses.

An open-ended style of interview and the use of depth-probing questions are important because it allows participants to speak freely and enables the researcher to follow a particular line that the participant introduces. It also obtains more details on a point or examples of something and the like. Participants were asked the same questions but the open-ended style and probing allowed me to explore more deeply on particular issues the participants raised.

3. 6 Data Analysis and Writing

Whitt (1991) states that the analysis of qualitative data is usually "a messy, ambiguous, time-consuming, creative and fascinating process" (p. 412). A chief challenge for the researcher is to identify emerging themes and patterns after the interviews have been transcribed. Mathematics teachers' attitudes toward reform – the barriers they perceive, their struggles to enact it, and so on – can be analyzable, according to the literature, in terms of the following basic themes, concerns, or dimensions: (1) role redefinition, (2) opportunities for professional development, (3) relationships with other educational stakeholders, and (4) structural constraints. With regard to role redefinition, a participant might claim that he/she is confused about being required to have students work in groups and discuss mathematical ideas and be more comfortable with the traditional role (in which the teacher tells and demonstrates curriculum objectives). A teacher might have mixed feelings about the usefulness of professional development programs. Some may feel that parents do not respond positively to the reform approach. Finally, teachers may point to structural constraints which work against reform goals – dissension in mathematics departments, outlooks of school administrators, and so on. Other

teachers may not have these concerns, although the literature indicates they represent a small minority.

Using the constant comparative method of analysis, I carefully read through each interview. Responses to each question were grouped and through the simultaneous comparison of the responses, similarities and differences were identified. Grouping was based on the positive or negative reactions to a particular question. Through this analysis, the commonalities were identified and these shared opinions emerged from the data to form key issues or themes in the teachers' experiences with respect to math reform provided in the qualitative data.

The four main aspects identified above guided the coding and sub-coding of the data. During the coding process I intended to examine the interrelationships between these aspects and determine how they are integral to teachers' attitudes and perceptions. Perhaps one of them, say structural constraints for example, would emerge as particularly important. Analysis may lead to theorizing. Hutchinson (1988) observes that there is a need for "middle range, data-based theory that explains the everyday world of teachers, students, administrators, and the school bureaucracy" (p. 126).

Qualitative research involves thick and careful description since it is possible that mathematics reform has a different meaning for individual teachers. The acknowledgement of their "voices" is vital. The use of verbatim quotations, which as Whitt (1991) states "convey the feelings, surface and deep meanings, and consistencies and inconsistencies of the insiders' experience" (p. 412), is needed. Using participants' statements, sometimes at length, in the presentation and analysis of data is standard qualitative procedure (Merriam 2002). This shows the researcher's attempt to have people express their voices and to empathize with their contexts and particulars. If, for example, mathematics teachers use words and expressions like "hassled," "discombobulated," "we're educational guinea pigs," "reform might work well in Japan or Heaven, but not in my school or my classroom," and so on, then such interview fragments should be included rather than the researcher superimposing his/her own language.

Thick description lies along a continuum. At one end are highly specific verbal communications which contribute to description. For example, a teacher might say: "The reform notion of student exploration and discovery might be okay for coming up with the formula for the area of a triangle because students can compare triangles and rectangles and with guidance come up with one half

base times height. However, for the volume of a cone – now that’s a different matter.” At the other end are non-verbal communications which may or may not be subtle. If a teacher shrugs her shoulders or rolls her eyes and simply says “Reform!” then much has been said by that gesture alone. I think that good qualitative writing should pay attention to all the nuances of voice.

In the beginning of research planning a researcher must determine which data collection process is best suited to meet the goal of the research. A qualitative research study provides a great opportunity for the teachers’ attitudes toward and perceptions of mathematics reform to be voiced.

3. 7 Reliability of the Study

The trustworthiness of the conclusions in this research was ensured by using suggestions from Miles and Huberman (1994). The data was analyzed with meticulous detail and quotes from the respondents were supplied to support the conclusions. As well, the study’s data is available for reanalysis if necessary.

The dependability of the study was affirmed through the providing of a copy of the research questions, clarity in the interview questions, and using an appropriate sample of participants for the interviews. In addition, the findings

of this study are consistent with those of previous research reported in the literature review.

CHAPTER FOUR

DATA PRESENTATION

In this study the goal was to develop an understanding of teachers' perceptions of and attitudes toward math reform. Specifically, the purpose was to determine how the issues related to math reform affect eight math teachers in the context of their working environment in Newfoundland schools. This chapter presents the findings of the interview data given by these teachers in an attempt to describe their experiences in the workplace. Structurally, it follows the interview format in its presentation (see Appendix E). A discussion and analysis of the findings will follow in Chapter 5.

The transcripts of the interviews provided a wealth of information from the participants about how they perceive math reform. They had varying opinions, of course, but all felt that their working environment was very much impacted by the curriculum expectations which math reform creates.

4. 1 Background

4. 1. 1 Teaching Experience/Training

With regard to teaching experience the eight participants ranged from three years to over thirty years with a mean of 14 years. Most had taught in more than one school with three being the most typical. For training, four had a degree in mathematics while the others had either a minor or a concentration in mathematics. Four teachers taught in the elementary grades (4, 5, 7/8 and 7 – Level III) while the others ranged from Grade 9 to Level III.

When asked whether or not their training had adequately prepared them to teach mathematics, opinions were divided. Half of the participants felt they were more than adequately trained, with one referring to the internship as the most valuable learning experience, and another found that his tutoring experience was particularly useful to gain an understanding of how students learn. The other half were not as positive on the question. One felt that it was not until he did his Master's courses that his eyes were opened as to how to teach math. Another felt that 80% of it you pick up in your first five or six years. One participant thought that there is not enough time to work with the curriculum and to know it and that there was a paucity of methods courses to learn different strategies and ideas, especially in primary and elementary. Still

another lamented that she was a primary trained teacher who ended up teaching in high school:

I had to start teaching myself because every time they changed – I think I have been through three, maybe four different curriculums (sic) and ideologies – each time they switched, I had to teach myself.

4. 1. 2 Experience as a Student

All respondents stated that their own experience as students influenced the way they teach mathematics. Several did not feel, however, that these were positive experiences. Two teachers said that they were taught through drill and practice and had a tendency to mimic that approach, at least at first. Another stated it was of the utmost importance that a teacher “get it across by coming down to the real world.” Still another said “My math teachers were boring and humourless so I try to incorporate my personality into my teaching, making it more fun through being friendly and approachable.” Finally, one respondent said, “I try to do the exact opposite of what was done for me.”

Two participants were more positive about how their experience as a student influenced their teaching. One noted the importance of thinking back to these times to remember “How did I figure these things out?, How did I solve

these problems?" to gain insight into the teaching process. Another responded that her successful teachers had helped her to be well-organized and to convey information effectively. Then, there was one respondent who said he was taught in the old-fashioned way – book, assignment, test – and could never get his questions answered. He summed it up this way:

I structure my classroom in a way that they will explore about the whys of math. As a student in university, I think about my students now on more of a personal level because I kind of relate to them. Like making sure they all have access to what I'm doing in the classroom and they are not lost.

4.1.3 Career Pathway

When asked about their career pathways, there was a variety of comments. One teacher had hopes of staying in a junior high setting teaching math; another wanted to stay in high school math although she was primary trained. Still another planned on doing a Masters in mathematics in the near future. One respondent contrasted his seven years in a rural school where he taught multi-grades with the different issues of the larger high school where he currently works. Another respondent told of her experience with many in-

services, Criterion-Referenced Testing (CRT) boards and even working with the Department of Education as a consultant from K-9. Finally, there was another teacher presently doing a Special Education degree who felt that there was not enough intervention for math at the lower grade levels. In her words,

We do readiness and phonics instruction at lower grades when reading skills are not where they need to be, but I don't think we are doing enough of that kind of thing for mathematics.

4.2 Classroom Management

4.2.1 Style of Teaching/Typical Class

With regard to style of teaching the eight respondents offered up a wide diversity of comments – from the elementary teacher who uses no texts, tests, or assignments in her problem-solving approach, to the high school math teacher with his more formal, disciplined classroom atmosphere. Nevertheless, there were many commonalities in their responses. Nearly all spoke of the importance of introducing topics carefully with linkages to the previous topic. All stressed the importance of being organized and structured as well as consistent in the classroom practices. Practically all teachers utilize pairing or small group work in their classroom. The majority describe their teaching style as an investigative or problem-solving approach although several admit to being

more traditional or using "chalk and talk." All teachers stressed the importance of monitoring student progress through such things as classroom observations and homework checks, and also interacting with the students individually to assist where needed.

Although several teachers recognized the necessity of whole group teaching, they did acknowledge its limitations in keeping students' attention. One respondent explained how she gave students little roles to play as volunteers to distribute calculators, for example. The participant who did not use tests and textbooks liked to give five minute warm-ups for review and utilized portfolios and math centers to keep the children active and engaged. Despite the emphasis on small group work, all felt that independent seat work is also critical. Working with concrete manipulatives was a recurring idea. As a matter of fact, one teacher stated all her classes are based on the learning styles of her students. She described her typical class as project-based and hands-on, with kinesthetic learners using manipulatives, and visual learners working with the Smart Board. Overall, on this question, a diversity of responses was given but with many recurring ideas and practices.

4. 2. 2 Accommodating Individual Learning Styles

With regard to accommodating individual learning styles, all respondents recognized that different individuals do have different learning styles. One teacher commented that some students will need manipulatives to solve mathematical problems while others can move quickly into abstract thinking. Another participant noted the importance of giving students choices to allow them control over their own learning, and felt that he has had much success with learning centers and appropriate pairings to create choices. One respondent stated that technology has helped him allow for individual learning styles with such tools as the tech calculator, the internet and the Smart Board. He thought that the different ways to instruct that these technologies have made possible, especially for visual representation, are so valuable and make learning interesting and enjoyable.

Many of the responses to the question on individual learning styles pertained to students with learning difficulties. Several teachers referred to providing notes to such students so they can focus on understanding rather than copying things down. They also mentioned extra help, more time for test completion, alternate settings, special pairings and class support from special services teachers. A couple of teachers referred to a wide range of

manipulatives, study guides, flip sheets, visual aids, projectors and videos which are essentially available to all, based on ability and interest.

On the other end of the spectrum, teachers also commented on gifted or bright students. Several spoke of providing extra problems, worksheets and handouts of a more challenging nature to stimulate their minds and alleviate boredom. Another spoke of special research projects, internet math games and other activities to sustain interest. One respondent felt that accommodating individual learning styles was often complicated by having to finish the curriculum on time and also by sometimes having advanced, academic and basic students in the same class. One teacher summed up his concerns this way:

I think the whole math program is taught the wrong way. It should be done in order to address the needs of all the different learners because they all do learn math. They just go through different stages in their understanding. We should teach them where they are and move them to the next stage.

4. 2. 3 Successful Teaching

From the responses to the question on what leads to success with students, several themes emerged. Along with good attendance (sometimes

compromised by students working outside of school), teachers expressed how important the students' work ethic was to success – how they need to put in a good effort. Three respondents identified how crucial it was for students to build and gain confidence in doing mathematics, often by small increments using “crutching” for example, and that success builds on success. Motivation was also mentioned as significant and that teachers need to interact with each student as frequently as possible, providing encouragement and positive feedback along with extra time and resources to foster better motivation in students. One teacher remarked that students should research and set their own goals both for the school classroom and for post-secondary schools so they can “buy into the program.”

Another key to success that was identified was teachers knowing the needs of the students. One teacher felt that the lessons should fit the learners and said she always does essential skills evaluations before teaching new concepts. Another thought that the supposedly “new concepts” such as pathways/inclusion and multiple intelligences are things that good teachers do and have always done to accommodate student differences. Still another respondent summed it up this way:

My ability to know the needs of my students leads to their success – their learning styles, interests and preferences. I also feel giving students choice gets them engaged and empowers them to be in control of their learning, and how they learn, and they can then show me what they have learned.

4. 2. 4 Unsuccessful Teaching

To a large extent, teachers in the study identified the reasons for lack of success in teaching mathematics to be the opposite practices and conditions of those which lead to success. For example, bad attendance records and poor work ethic were cited, as well as lack of motivation. One participant stated that children sometimes become disinterested in class if teachers do not really know them and do not keep them engaged and consequently, very little learning occurs. Two respondents identified the need to teach students to be more independent, and that it is all right to fail sometimes and not to constantly look to the teacher for “the answer.” One teacher explained that students are sometimes taught too much too soon and they are not taught at the developmental level of what they are capable of understanding. Finally, there

was acknowledgment that students sometimes do not have the pre-requisites for their grade level:

Many students are unsuccessful when they come to me with deficiencies in math that's been carried forward, probably from elementary school.

Instead of having times tables memorized, for example, they have to use their calculator to do simple arithmetic.

The important role of the parent was also identified as a crucial factor in the success of students.

4. 2. 5 Problem-Solving vs. Drill and Practice for Student Success

When asked whether students experience more success with the problem-solving approach or using drill and practice, the participants in the study were divided. Two chose the problem-solving approach; four cited drill and practice as more effective; and two endorsed a combination of the two.

Of the two who selected the former approach, one explained that coming up with strategies and utilizing them is far superior to drill and practice for the transferal of skills. The other supporter felt that through the problem-solving approach, she was able to raise CRT scores in her class so that they were higher than in any of the previous years in her school's history.

Of the four who preferred drill and practice, one said she liked that more structured approach and that the investigative method can be very difficult for many students who need to be led through small successes and being shown examples of what is expected. Another concurred, comparing learning math to driving in winter, stating that the only way to develop "automaticity" was through constant practice. A third supporter thought that students with weak ability in mathematics can better do drill and practice because they are following a kind of "recipe" whereas problem-solving requires higher-level thinking which many students find difficult. Finally, another respondent noted that drill and practice works better for such processes as factoring, FOIL (First Outside Inside Last), teaching quadratics and logarithms which are characterized by certain rules.

As mentioned, two teachers felt the two approaches were not conceptually incompatible paradigms. One cited times when drill and practice is needed and other times when it serves no purpose. She thought children do need strategies to solve problems but that the entire math program should not be centered around it. The second proponent of a combination approach supported the dynamics of the investigative model but felt, like in basketball, students only improve with practice. She commented:

There has to be a balance. I think what happened was they went hog wild one way to investigate everything, which is lovely but you would need three years for every one-year course, and then they went back to drill and practice which was too much of that. A nice blend of the two is what works best.

4. 2. 6 Long-Term Retention of Skills

Half of the respondents in the study held the opinion that long-term retention of skills is better facilitated by the problem-solving technique than drill and practice. One teacher felt that, "when you get down to it, it's really the strategies that students retain, and that drill and practice leaves them with nothing to work with." Another reiterated that students retain more through problem-solving because they have to work through situations and figure out what strategies they need to use. Still another stressed that in problem solving, they are thinking about what the problem means to find a solution and because they are so engaged, they will remember it because they find it meaningful. Finally, the fourth respondent felt problem-solving could be applied to other situations and could be retained longer over drill and practice which he

described as essentially memorizing a certain recipe, not really understanding it and therefore, the retention is not there.

On the other hand, two of the respondents stated drill and practice produced better long term retention in students. One of those interviewed thought acronyms, like FOIL for example, would tend to stick in their minds more so than problem-solving techniques. Another simply subscribed to the axiom that practice makes perfect and that it is the best method particularly in elementary school. The final two respondents were more "on the fence" regarding the issue. One was of the opinion that, when children explore topics they tend to retain what they learned but she also found students perform better if they get a lot of drill and practice, basically performing tasks numerous times. Finally, another respondent with mixed feelings stated drill and practice works but a certain amount of understanding is also necessary. She expressed her feelings through this metaphor:

If you don't know why you don't cross the road when the driver to your right has a green light, it doesn't matter – you will still survive in this world if you don't cross the road when the light is green. But to hold on to something, you have to understand it, to have an interest in it; a love for it, for it to be your passion, yes.

4. 2. 7 Meeting Curriculum Outcomes

Opinions were definitely divided over how difficult it is to meet curriculum outcomes. Two respondents felt that specific curriculum outcomes (SCO's) could very readily be met using the problem-solving approach since, as one stated, "For any one given problem, you are probably attacking at least ten outcomes per problem." The other positive respondent said she had trouble at first but by incorporating math into the other subject areas, it could be accomplished and given more relevance in the "realistic world."

Of the three participants who replied in the negative, one responded that the Department's new investigative approach takes much longer and that teachers sometimes resort back to drill and practice in order to finish the program. A second felt that there are simply too many SCO's and students do not move fast enough and that broader curriculum outcomes should be instituted. A third commented that she has never finished the Grade X curriculum in any of her eleven years teaching it, and that the problem is usually the high level of deficiency in the students who do not have the pre-requisite math skills.

The remaining three respondents had mixed feelings on the subject. One felt the SCO's could be met but that there was a significant number of students

who lag behind because of the compact time frame and require tutoring and out of school assistance. Another teacher thought he could do justice to it but that he is required to “teach too much and that the curriculum powers that be may understand math but they don’t understand how a child learns”, being too focused on their own agenda and not fully cognizant of what children are capable of understanding. Finally, the last participant recommended a balance between “how much you investigate and how much you teach directly” to meet SCO requirements. She stressed how important it was to have well-trained teachers with reasonable expectations (not too many outcomes) in a sensible time frame. She summed it up this way:

You have to have a few less outcomes that [students] really learn than a pile that you are rushing through so fast that they are not retaining anything – building the foundation on one level for what you are doing on the next.

4. 2. 8 Supplementing the Specific Curriculum Outcomes

The majority of the respondents (six out of eight) felt that they are able to supplement the course SCO’s to accommodate individual student needs although some did have qualifications. One teacher uses supplementary

material to explore topics a little further depending on student skills and attitudes but not so much with academic courses. Another felt compelled to pursue extensions of topics of interest to students to facilitate long term retention, although she acknowledged that such discussion was not always possible because of time constraints. A third referred to the same issue with time but does take a couple of classes per unit for fun activities and games as alternate ways of instructing.

Other respondents felt that SCO's could be supplemented but that there were limitations. For one, it was problematic from a time perspective but was greatly facilitated when a special services co-teacher was able to help.

Another stated that having to repeat investigations and re-teach topics for students with "borderline basic" skills often pre-empted any kind of enrichment. Another indicated she was trying to get away from unit-based work and incorporate different math strands into her teaching and that this has enabled her to meet the outcomes and have a bit more freedom in her class. Two respondents were more emphatic that they did not supplement SCO's to any large degree. One stated he was "pretty outcome-oriented" and that was the focus other than sometimes using technology to broaden the outcomes. Another acknowledged that he could deviate in every other subject but in math,

the “amount of stuff to be done” tends to dictate that he goes “Here are the algorithms, plug in the numbers, and move on.”

4. 2. 9 Enrichment Activities

All respondents identified some type of enrichment in their mathematics programs. Such activities included extra work (i.e., higher level questions, drawing from outcomes in the next grade level and even extra courses in one particular high school context). Working with the calculator and extra units on such topics as graphing and tessellations, were also identified. In one instance, gifted students were assigned to one teacher for specific classes where they did enjoyable activities like work puzzles, brain teasers and such to enrich their math program.

4. 2. 10 Extra-Curricular Activities

Most respondents indicated some kind of extra-curricular activities for their students in mathematics. Four teachers replied that their students did Math League competitions particularly for junior high; and four also named the Waterloo contests – Pascal, Cayley, Fermat, and Euclid. The Blundon contest from MUN was mentioned by one participant. Two schools were reported to

have lunchtime enrichment activities which in one case ran for a whole week and in another case, involved creating a scale model of the school. "Kangaroo Math" for the lower grades was also mentioned as well as a math-driven relay race. Only two respondents replied there were no extra-curricular math activities for their students with one K-6 teacher explaining that "we can't participate in anything because of where we live."

4.3 Math Reform

4.3.1 What is Math Reform?

The general understanding of math reform was that it was basically a movement towards an investigative or discovery style of learning as opposed to the traditional drill and practice model. The majority of teachers used these terms to describe math reform as well as "math exploration" or a problem-solving approach intended to get students more active in learning. Two thought it had been around for ten years and another mentioned longer than that, with one of the former stating it was brought in at the Grade X level.

For one respondent, math reform means "rethinking" math and getting back to its practical roots and realizing there is often more than one way to solve problems. Another felt that teachers are not doing the investigations and

following the textbooks, but rather are supplementing the material with workbooks. He also stated that the "new" math is really not that much different except for, in his own case, including transformationals and incorporating statistics into all courses rather than it being a separate course.

One teacher was of the opinion that the Grade VII program was actually getting away from the "new math" because it is investigative at times, but it also involves a lot of direct teaching. She liked the current books better because they included more resources with good practice and worked-out examples, something lacking in the previous books and this deficiency, in her view, served as an impediment to students and parents trying to use them. She also felt that, like training wheels on a bike, modeling in teaching should be discarded when the students have "gone to the algorithm."

Another respondent lamented the way she had been taught math with the teacher giving out information, doing problems that she did not really understand and having to memorize formulas. She described math reform this way:

Math reform for me means that there has been a shift from a procedure knowledge base to a conceptual one, where students are being challenged

to use the knowledge they are gaining and apply it to problem-solving situations. It's less about procedure and more about them understanding why they are doing what they're doing and relating it and connecting it to other different strands.

4.3.2 Does Math Reform Work? Do You Support It?

Of the eight respondents, two stated that drill and practice works better for them, two thought that math reform does work and four were positive but with qualifications. In the latter category, one teacher remarked that it can be quite successful but only if the students are efficient with the prerequisites since the investigations assume that the students have mastered them and unfortunately, often times they have not. A second in this group objected to the drastic way reform was implemented, bringing it into Grade X after students had gone through K-9 doing drill and practice and expecting students to learn a different way and that teachers teach a different way. The third felt it was not working because kids are not performing well on CRT's and teachers are not being given proper and timely in-service. The fourth did not elaborate.

Of the two participants who were more supportive of math reform, one stressed it works well if the teachers have confidence in themselves and have a

vested interest in it, while the other was a proponent because he thought math reform helps us to rethink math and offer the students more alternatives. The two respondents who preferred drill and practice did recognize math reform had strong points in its favour, but they seemed to think many learners could not take that “higher end approach to the exploration” and that organized, structured lesson plans were the best means to achieve curriculum outcomes.

The question of whether the respondents supported math reform brought answers consistent with the previous question. Most said they supported it although several did have reservations while two did not support it. Those who supported it liked the fact that it gave students alternatives and the freedom to discover. Those who did not cited problems with implementation, in-servicing, and student lack of pre-requisites and poor adaptability for higher level learning. One teacher stated that there should be a combination of both investigation and drill and practice to foster skills. She supported the exploratory benefit of math reform but felt the approach was not always time-efficient or conducive to keeping students on task. One teacher commented:

I deal with parents who say “Why are you teaching the students that way (the problem-solving approach)? Just teach them the right way and they

will learn it." But they need to understand that there is more than one right way.

4. 3. 3 Does Math Reform Increase Demands on Your Time?

All respondents stated that the "math reform model" placed more demands on their time and most were emphatic about it. For three teachers, it was because getting materials and resources for the investigations was problematic, not to mention the methodology itself was not always time-efficient in the classroom. As one of these teachers explained, "The new investigative approach involves a lot more prep time than doing a few examples and assigning twenty questions on a concept."

For another participant, the time-consuming aspect was figuring out the different possibilities that the students may discover, the strategies you are going to teach, generally differentiating the lessons. Still another felt so much time was expended covering the gaps in the students' understanding because they lacked basic numeracy skills. One teacher stated that the texts and the curriculum documents do not support math reform, and there are not a lot of teachers or board personnel who know how to implement it. However, she maintained that it works and it is worth it although it takes a lot of time.

Another respondent concurred that demands on her time were excessive but that when courses were better laid out with closer matches between curriculum guides and textbooks for example, the demands are diminished. Finally, there was the opinion that better in-servicing and training, perhaps even including a course being offered to teachers, could better facilitate the implementation of the reform model.

4. 3. 4 Obstacles to Meeting Reform Expectations

Several obstacles to meeting reform expectations were identified in the study: time constraints, students' lack of ability and motivation, lack of support, flawed course design and insufficient in-servicing. Two respondents mentioned time constraints and that the investigations take too long, leaving no time to actually practice on the topic and that teachers were not well prepared and were expected to change overnight and so were the students. Students' lack of ability for the investigative approach was cited as an obstacle and it was noted that teachers often revert back to algorithms that work to allow them to cover the curriculum and satisfy accountability. One respondent noted that motivation is sometimes a factor and that having students solve problems on their own works better in theory than in practice and that at least with drill and

practice, you can actually see what they are doing. A lack of support was mentioned along with the fact that sometimes courses are not laid out well with a poor match between curriculum guides and textbooks. Finally, two respondents referred to a lack of proper in-servicing with one feeling teachers need the opportunity to voice concerns and to learn together to feel more comfortable doing things in a different way and the other suggesting teachers be offered courses as previously mentioned.

4. 3. 5 Have Teachers Modified Practice for Math Reform?

The general opinion from the study is that math teachers as a whole have not been able or willing to modify their practices in response to math reform. One respondent said that she thought teachers are just not “discovering it themselves” and three responded that teachers have tried it but found it too difficult or time-consuming and have reverted back to drill and practice because the latter was “more organized” or was more conducive to better performance and accountability.

For one participant the problem is that a lot of teachers do not know about math reform, and misunderstand the problem-solving approach, thinking it can be taught by the book when in her mind, the book has nothing to do with

problem-solving. Another respondent felt that some have adapted and others have not, primarily because the focus is not on the curriculum outcomes where it should be and it needs to "be understood that a resource is only a resource." There was also the opinion that effective and timely in-service and training are so lacking that the problem-solving approach has not been given a fair chance. One more positive opinion was that teachers, being resilient people, are incorporating investigations and drill and practice into their teaching as they always have. She explained that "with differentiated learning you really get to take a lot of different approaches to it. Differentiated learning is just a new catch phrase for stuff we've been doing for years."

4. 4. Teacher Support

4. 4. 1 Competence/Support for Reformist Goals

With regard to competence in enacting reformist goals, practically all respondents stated they felt competent in teaching mathematics but not necessarily the goals of reform. Half the teachers stated that their confidence in the new ideology has taken a period of time to develop and has generally come primarily through their own initiatives and effort. One such teacher felt competent only because she has attended national conferences, worked on

curriculum guides, and spent time with teachers who share her philosophy and vision. For one participant, although she felt competent and capable in teaching math, she thought the competence of many K-6 teachers has been unjustly undermined because the Department attributes problems with the program to the erroneous belief that the teachers can not teach the math. Another respondent did not address the question of competence because she "was not really familiar with reformist goals."

On the subject of support, almost all teachers responded that support was either inadequate or inappropriate. One teacher in the study stated she did not feel supported because she has not been shown how to utilize her time in the actual teaching and has to incorporate drill and practice to use time wisely and have students achieve success. Others replied that if not for other teachers teaching the courses or training from outside sources (as previously mentioned) there would be no support. For another participant the problem was that teachers were unqualified because they have not been given enough time to know the courses and that teachers were coming out from MUN not knowing, for example, how to make up tests with questions that reflect the weighting for the various outcomes. Two respondents felt the Department has failed in the way they have implemented the program. For one, it is the fact that they did

not start the program in Kindergarten in the beginning, and that there has not been enough in-service or support from the district level to clarify expectations or provide resources. For the second, it was the same problem with implementation and professional development (PD) as well as unavailability of books and that the itinerant teachers hired as supports were not necessarily lead teachers or were not especially qualified for that position. Finally, one participant did feel supported in her local school because the staff tends to help each other and share ideas and expertise, and she is very positive about the math itinerant teachers although her school could not avail of one.

4. 4. 2 Assistance in Teaching the Reform Approach

For the most part, teachers in the study reported that more assistance was definitely needed to successfully implement the new programs. Two respondents stated that they have received very little assistance but despite this, they are the ones giving others help (i.e., conference calls, providing “shadowing” for novice teachers because of their experiences). For one, she would welcome more collaboration and sharing of ideas. Another teacher thought resources are lacking and more assistance from the district level is needed by getting the teachers together to discuss progress and show teachers

how to enact the curriculum especially during pilot courses. A couple of participants would prefer more "hands-on in-servicing" while another felt smaller classes would lead to more success with the new approach since some of her classes have numbers in the high thirties and have a diverse range of learning needs including students with autism and Tourette's Syndrome.

On the more positive side, one respondent felt that the new Grade VII program was a step in the right direction with its extra worksheets and pre-done tests. Another replied that her school did a lot with sharing resources and that First Class was particularly useful in facilitating communication with program coordination at the board level. One improvement, she felt, would be to reduce the number of outcomes for courses and to work toward better communication between parties on all levels.

4. 4. 3 Access to Resources

One theme that was prominent regarding resources (over half the respondents identified it) was that the department and district were not providing adequate resources, and that the teachers feel they have to use their own money to supplement what is being provided. One teacher felt that all the necessary resources should be given up front and that all teachers starting a

course should have their own manual and teacher resource book, which is not always the case. Another said she buys her own membership to the NCTM website ("her Bible") because of budget constraints. For yet another, she commended the Grade VII program with its compact disc (CD), resource guide and practice book, but when she requested an additional binder for the program, she was told the school could not afford to buy it. Finally, another respondent described the limited resources and explained she has to use her own laptop and had to buy a projector.

There were more positive responses in the study, however, to the issue of resource accessibility. For one teacher the internet has increased the availability of resources significantly, although he felt the department should furnish more worksheets and such to clarify what is expected of students. The new Grade VII program was praised by another participant for its excellent book and supplementary resources. The Eastern School District was also applauded for providing some good resources like Microsoft Office 2007, FX Surreal and programs like Math Type. Finally, for one respondent it was a question of creating her own resource base, stating that, through her efforts, her school has an entire math resource room and all classrooms have resources based on their curriculum. She referred to calculators, clocks, overheads,

pattern blocks, along with a math board in the staff room containing basic manipulative sheets and research articles to boot.

4. 4. 4 Supplementary Materials of Your Own

Five participants specifically referenced that they use their own notes, old books and other resources as supplementary materials and the other three implied that they did also. Practically all said they had their own unique set of notes which they develop to suit their style of teaching, often using their own knowledge as a base along with materials from many sources. One teacher who had been teaching for eleven years mentioned he had his own workbook as well, while another still “resorts back” to old geometry and algebra textbooks. Another respondent acknowledged the curriculum guides and outcomes but still feels it necessary to “tweak those things to your own style of teaching.” Finally, one interviewed teacher hoped that the need to supplement materials would be alleviated in the future:

Hopefully with this new reform in Grades VII, VIII, and IX, there won't be a need to depend upon other resources. Everything you need plus more [will be provided.] There's more there than you can actually teach.

4. 4. 5 Other Useful Resources

A variety of useful resources were referenced in the interviews. Two respondents endorsed a supplementary resource book by Todd Sharpe which they described as “a drill and practice type of book.” Naturally, Smart Boards and online resources were affirmed including the Aliant Learning Centre and the National Library of Virtual Manipulatives. The NCTM journals were highly commended for the relevant and exciting activities they offer, as was the NCTM Navigation Series, which involves books written on strands on such topics as geometry, measurement, number and operations and include activities for student exploration, “what reform is all about,” according to one respondent.

Finally, the Centre for Distance Learning website (CDLI) was also given a strong endorsement. “They have all their units laid out. It’s all visual on the board. They have little interactives, audio clips, telling students how to do things step-by-step, the algorithms of mathematics.”

4. 4. 6 Professional Development

Almost all respondents were critical of the amount and/or timing of professional development. For one, the problem was it was offered when the teachers were “knee deep in the curriculum” and many topics were already

covered. Another concurred that the PD was done after the actual implementation (October for September). Still another complained that her PD was watching a DVD of "four or five people talking about the course." One respondent thought that teachers who piloted the courses "got good in-service" but after that it was "here's your book and carry on." Another participant remarked that teachers did not understand, for example, the rubric for CRT's – communication, reasoning, problem-solving – and that there was nobody at the board or department level with the interest or ability or the will to rectify the situation. There were also comments that most in-service is repetitive and that only university courses would be a source of improvement for one respondent; that a lot of PD involved Smart Boards which are not always available; and that much of the PD is focused on school growth which is more talk than action.

There were some positive comments that the PD helped one teacher to be familiar with the book, the curriculum and the guide through the offerings in both the spring and the fall. Another thought the ESD is doing a better job especially in Grade VII with PD being made available in both June and September although more is needed, perhaps even a three month course on the new methodology. Finally, another respondent remarked that she has been

given adequate PD only because she sought it out but she did not feel what was mandated is sufficient.

4. 4. 7 Improvements to Professional Development

In terms of improvements for professional development, five respondents felt math teachers need more in-service than is presently provided and of these three remarked that the PD should be done before the curriculum is implemented. As previously mentioned, one respondent felt a course should be designed and presented for teachers on the new methodology. Four respondents identified that more professional collaboration and resource sharing should be happening. Specifically, one felt teachers should be encouraged to spend time in each other's classrooms doing hands-on activities, and that schools should do their best to facilitate these exchanges particularly for new teachers. Two others spoke of getting relevant teachers together in small groups to discuss their courses rather than sessions en masse. Others thought the department should provide more practical resources and more direction and clarity with regard to curriculum expectations. Two respondents referenced the Western Protocol and essentially thought that if we are to emulate that curriculum, then

we must also be willing to increase the amount of in-servicing and support to keep pace with the Western Provinces and we have not traditionally done that.

4. 5 Stakeholders

4. 5. 1 Parents' Attitudes Toward Reform

Five of the eight respondents in the study felt that parents have negative attitudes toward reform. One thought the parents were frustrated because "it's not the way they have been taught," and the investigation approach is new to them and that makes it very difficult for them to help their children. Another said that parents have difficulty with it because they see their children struggling with discovery learning and complaining about it as well as seeing their marks drop. One spoke of a parent who was an engineer and another who was an accountant who could not assist their children with homework because these professionals were not familiar with the method and approach, or models and manipulatives and such. With comments like "There's nothing in the books, not even one worked out example," at least two parents have had to resort to hiring tutors for their children. According to another respondent, parents are used to, "This is the algorithm, plug it in and that's it, no thinking

involved, so when they see the lattice method or a tilted square (which the children understand better) they counteract what she is doing and undermine it.”

On a more positive note, one respondent said that parents do not know enough about math reform to support it or not support it, and that eventually, after the kids have been immersed in the problem-solving approach, the parents will support it because they will see their children “getting it.” Another thought some parents support it and some do not, but the main problem is that parents have not been included, and that parent booklets can help facilitate a better connection between home and school. For another respondent, the new Western Protocol, with its more organized structure, will be better received by parents because the books will be better organized and kids’ notes should support that and “that’s what parents like.” Finally, in another teacher’s opinion, she hoped the new books would all be like the new Grade VII because they have step-by-step problem solutions, and parents can see exactly how the model works.

4. 5. 2 Department of Education and Math Reform

The question of why would the Department of Education support math reform drew commentary along several lines. Two felt that emulating the

ideologies coming from the United States was not necessarily wise since they historically perform worse than Canada in mathematics. Another thought there was an inability to commit to reform since the leadership in the department was always temporary and subject to the whims of politics. For another, it was the fact that the university is crying out that students do not understand math that is driving reform. One respondent stated that the Department of Education wants, in a perfect world, better students who can handle problem-solving strategies and apply them to new situations. He further explained that students must, however, also have a good level of reading comprehension:

The book is often full of word problems, less numbers, less drill and practice, and if a student is weak in reading comprehension, he/she would be lost. Essentially, the textbook [becomes something] for a more advanced student.

Several respondents endorsed the new direction for the Department. For one, it was that "the research is showing that doing math this way gets the best results" and that, because we are becoming a technological world, we are becoming a world of problem solvers, and children need to be able to solve problems. There was also the opinion that "kids need to know what they are

doing, and why they are doing it" and they need to be able to explain it in words and support it as well as do mental math activities to promote thinking.

Another suggested that the Department was concerned with the low percentage of students actually passing academic math and that, if it truly invested in math reform and provided the necessary resources, a drastic change could occur for the better because students who are adept at problem-solving would be better prepared for post-secondary education. Finally, one respondent thought that there were bigger issues here, much broader than math reform:

I think changing the curriculum and approach is not necessarily all they have to do. They have to start putting some things in place that have nothing to do with the math curriculum at all but with the students being taught responsibility, diligence, how to study. We have to instill in them this idea of a work ethic, and it's not being done.

4. 5. 3 Piloted Courses in Relation to Math Reform

In response to the question of whether or not they had piloted any math reform courses, three respondents replied succinctly that they had not and a fourth said she had not but was a student of a piloted course in Grade X. (She stated she "didn't like it very much and it wasn't good.") Two others stated

they had not either but one related how his school had dropped the new Math 1204 pilot that his colleagues were doing because it was so confusing and had not been implemented properly. For the other, she also had not piloted courses but she had helped to write curriculum guides and so she felt this work kept her very involved in the process.

For the remaining two respondents who had piloted math courses, one benefited from the guidance of one of her cooperating teachers and became very successful and a good resource for other teachers when she moved to a new school, the other had done all of the high school program. One respondent also commented that to her knowledge, the new WNCP curriculum has not been piloted but rather, "They just said, 'Here's the curriculum, here's the resources, see ya later, have fun with it.' "

4. 5. 4 Department of Education's Response to Feedback

When asked about the Department of Education's response to feedback, four of the eight participants replied in the negative while the other four were positive or at least recognized signs of improvement. Of those who indicated no, one respondent felt that you give the feedback but the in-service is so far behind that it's too late to change anything and it's a "done deal" by the time it

gets to teachers. Another was disappointed that she helped write documents about the module books they had, but the changes they requested – more examples, more questions and practice – were not addressed at all, and the module books and the textbooks ended up being “pretty much identical.” For another, the problem was that the Department responded quite favourably to her complaints regarding too many outcomes in the Atlantic Provinces curriculum courses but that these complaints were overruled by the other provinces because they had different issues. Finally, a fourth respondent was critical because she felt the K-6 teachers were constantly saying that the children were struggling with math and the CRT’s confirmed it but it was only when media and parental pressures came to bear that the Department put 25 extra support teachers in place and moved toward the WNCP math curriculum.

Two of the four respondents who replied more favourably also referred to the Western Protocol. One thought that the shift to the WNCP curriculum is evidence that the Department is getting the message and that the emails and course discussions as well as the request for input are good signs, although there is still a ways to go. Two others also felt that the Western Protocol is an example that the Department is responding to the concerns of teachers, and that changes to the use of DVD’s for in-services also reflects a positive response to

teacher feedback. Finally, one participant reflected that the department heads of schools represented the best avenue for collective feedback and that hopefully, the Department is recognizing this fact.

4. 5. 5 Teachers' Responses to Math Reform?

Practically all of the respondents who addressed this question did not think teachers are responding well to math reform methods. Two were of the opinion that some teachers are and some are not and that it seems to be working for some and not others. Another felt there were no checks and balances put in place to monitor the new approach and that, in her view, department heads are too "snowed under" to know whether it is actually being implemented in the classroom.

For other respondents, the problems related to implementation. One said that math reform is just one of the many new things being "thrown at teachers." There was also the comment that teachers are not getting enough direction on how to implement and present it and consequently, students are having major difficulty with it, prompting some teachers to revert back to drill and practice. Finally, one participant replied that teachers are not responding to math reform methods because "they are not used to teaching that way and a lot of them don't

know anything about this math reform.” He felt it may work fine in theory but in actuality, it is very difficult to operationize.

4. 5. 6 Courses Affected by Western Protocol

Only four respondents in the study addressed directly the question of whether their courses will be affected by the Western Protocol. One said she taught Grade IV math, and that Grades IV and I would be the first groups affected because of the CRT's. For another it was Math 1204 and 1206 which were supposed to be implemented in September 2010 but have now been put off until 2011-12. The respondent thought this was a good indication that the Department wants to ensure that things are ready before the new protocol is implemented. Stating that probably all his courses would be changed, another teacher thought the pre-calculus looked impressive and finally, another participant simply said she liked the new books.

4. 5. 7 Degree of Consultation on Western Protocol

Practically all the respondents in the study said there was no consultation with them before the decision was made to introduce the Western Protocol. Despite this fact, there was also no dissension about the move. Two teachers

simply stated that they understood that the decision to adopt the Western Protocol came through means of a committee "on a higher level." Another thought it resulted from dissatisfaction with the current curriculum and was an attempt to "bridge the gap between the math reform and the drill and practice, a blending of the two." Still another replied that she was not consulted but does "support the WNCP as an excellent approach to teaching mathematics."

Four respondents, despite not being consulted, did acknowledge some opportunities for input and/or feedback. One stated that she helped to develop the curriculum for Grade V following the Western Protocol while another thought her opportunity to give feedback during PD was a positive experience. Still another had given feedback on the actual curriculum objectives for the practical, the academic and the advanced courses, and finally, another responded that he had assisted on line with course feedback and was optimistic that the Western Protocol will be a move in the right direction.

4. 5. 8 Implications of Math Reform for Teachers

Several respondents (about half) in the study felt that the math reform and specifically, the Western Protocol will create extra workload for teachers. One participant said that anytime a teacher experiences a new course or a

change in curriculum outcomes, you have to develop it to your own unique style and that takes time, especially in your first year. Another concurred on extra workload, especially if "they don't provide you with the proper resources." A third participant believed that the new curriculum will mean a tremendous increase in workload, not to mention time-management issues and the fact that students often do not have the academic ability or the pre-requisites for the courses, and the supports may not be sufficient. Two of the respondents tended to disagree with the others on workload. One felt that although workload may increase at the beginning, resources which match the curriculum outcomes will be provided and lead ultimately to much less workload; and the second thought if the Grade VII curriculum was any indication, the workbooks and Blackline masters will actually reduce workload.

Several comments were made regarding teaching style. One respondent stated that he will probably continue to teach the way he always has, and he recognized that "the curriculum outcomes may change but that's not going to change how I teach them." Another agreed that his style will not change because he has always used a "different approach" including grouping students based on need for extra help or practice. Still another believed that "the style of teaching will change only if the Department gives enough direction and ...

provides examples and time to make the adjustments.” Finally, another teacher stated that “everyone assumed the Western Protocol will be less work when in actual fact, it will be more because it has two other strands – a visual strand and a tech strand.” She actually feels the WNCP approach is less integrated and more static than its predecessor. Rather than going back to basics, she explains the WNCP this way: “The Western Protocol [just] takes the NCTM [documents] and narrows it so that it has more focus per grade level. That’s all they have done.”

4. 6 Evaluation

4. 6. 1 Assessing Math Performance

With regard to assessing math student performance, each respondent in the study generally focused on one of the two methods of assessment – formal and informal – depending to a large extent on the grades he/she teaches. In relation to more formal assessment, one participant said the ESD has laid out how students are to be evaluated with a percentage for tests, one for assignments and so much for portfolios and journals. Another concurred that summative evaluation is dictated by the ESD including even a common Grade VII final exam. For still another, traditional tests and quizzes, projects, journal

writing, observations and homework checks comprised his means of assessment. There was also the opinion that 60% coming from tests was sufficient because "one of the most challenging [issues in evaluation] is finding alternate math assessments to paper and pencil methods" and therefore, she endorsed assignments, journals, poster presentations, homework and mental math exercises as well as the testing component. Concerning tests, another participant felt it was crucial that the tests contain challenging questions to encourage students to show their thinking and reasoning skills and that the tests also be based on the rubric.

On the subject of informal assessment, one respondent thought the most beneficial was informal observation "where you actually go around and help students" as well as homework which she described as "the catalyst" if a student is going to be successful. Another respondent stated she does not give tests but rather relies upon anecdotal records of observations, centres, project work, interviews and home portfolios. As well, there was another teacher who did not give tests or assignments but rather described her assessment scheme as "outcome based" using charts based on the rubric because "the report card in Grades K-VI is all rubric based." She is also a strong proponent of "open

response questions” and “uses observation and anecdotal reporting to inform [her] instruction.”

4. 6. 2 Homework

The majority of the respondents in the study (6 out of 8) stated homework was important for students and were strong advocates of its usefulness. Three teachers mentioned something in the range of 20-30 minutes two or three times a week would be reasonable, with a bit more for test days. One respondent suggested at least two hours for high school students, one hour for Grade IX and a little less for the lower grades. Several felt that it was important for students to finish up class work not done to be prepared for the next day and to practice things they found especially difficult. They generally concurred that too much homework can be stressful for students and parents, and that setting homework can be problematic where several teachers are involved. Two teachers felt that stakeholders might be regarding homework as not as important as it once was and seem to be endorsing more limitations on homework. Another respondent stated that the curriculum doesn't allow for as much practice as is necessary and a little practice (15-20 minutes a night) can help make the skills “embedded.” Finally, there was the opinion that “small

doses on a regular basis" was fine – learning times tables, some practice on equations – but kids do not need to be over-loaded, so 30 minutes would be sufficient for a ten-year-old.

Two respondents in the study stated they did not give homework. One felt that oftentimes if students do not finish work in class, it is because they do not understand it and assigning it for homework only brings added stress to the student and possibly the parents. The other respondent teaches Grade IV and concurred on the stress issue, and, other than reading logs, she assigns very little homework.

4. 6. 3 Teaching to the Test

Three of the eight teachers interviewed in the study thought that public exam courses are taught "to the test." One respondent of the three stated that it is a good tactic because seeing "prior examples" helps students be less stressed and leads to better performance. Another agreed with teaching "to the test" but insisted that he teaches the curriculum outcomes on which the tests are based so they are one and the same. For a third, he teaches that way partly because the public exams are so predictable anyway, and with standardized testing so prominent (CRT's in Grade IX, publics in Level III) you have little choice. He

supported teaching to the test in that it prevents teachers “going off in all different directions” but does feel a “happy medium would be ideal.” Two teachers of lower grades acknowledged that there is a defined curriculum for which teachers are accountable and they often feel “under the gun” because of CRT’s and doing CRT practice sessions helps students to be familiar with how questions are asked.

Three respondents replied that they did not support teaching to the test. One said that, although he personally does not feel the need to, many teachers do and that is their focus. Another simply thought mathematics was such that “you have to teach all sections to be able to understand the whole unit” so there is an organic wholeness about it that works against teaching to the test. Finally, another participant maintained she did not teach to the test but acknowledged that Grades III and VI are CRT years and she did recognize that there are certain skills students need to know to do well on CRT’s, and that she does provide them with activities and opportunities related to these skills including how to write constructive responses.

4. 6. 4 Pressure From Common Tests

Virtually all the teachers interviewed in the study acknowledged there was pressure to have students perform well on common exams. For one respondent, it was simply, not wanting her class average to be lower than anyone else's. Three respondents replied that the results are often analyzed and compared and in one teacher's words, "you don't want your [poor] results to be on a slide in someone's PD [presentation]." Another felt the CRT's in Grade IX presented similar challenges but stressed the point that that particular year is only one year and that there are many variables and factors at play pertaining to who should be held responsible for these particular results. For another respondent, the pressure took the form of having had very successful CRT results one year and then being expected to replicate the success the following year with a weaker class. Another teacher cautioned against using old CRT's as a guide because they change each year and the abilities of students in the classrooms also change from year to year. Finally, for one teacher, the frustrations of seeing sub-par results in meetings with parents or posted on websites could be alleviated by more realistic expectations:

Students are not all the same. They live in the real world where things go wrong sometimes. If you got basic students in academic classes, the

chance of success is very low. It's unrealistic to expect that all kids will be able to perform well all the time.

4. 6. 5 Time Spent Preparing for Common Exams

All of the respondents reported that they reviewed for common exams but the amount of time varied significantly. Two teachers replied that they use the last two weeks "going over old exams, focusing on possible questions and issues" but in the case of one, only after curriculum outcomes have been satisfied. Another participant stated that scheduling Math 3103 as a two-credit course allows Level III students in Math 3204 three to four weeks for review for the public exam. For another teacher, getting the curriculum finished before exams start is usually a challenge, and she is lucky to get a week to do some "good summarized review classes" and some sample exams before the final. Three respondents said they did not spend an inordinate amount of time in this regard, with one saying she would prepare students the same as for any final, with a standard amount of time for review, and another commenting that she just helps them with things like reasoning and math language.

4. 6. 6 Are Students Today Better Prepared for Post-Secondary Education?

Practically all the respondents in the study said that students today are not better prepared for post-secondary education with 6 out of 8 answering with a resounding no. One felt that since the investigative approach was introduced, students are performing worse in university courses prompting MUN to bring in placement tests to gauge students' math abilities. Another agreed and stated the reason was the students have been subjected to a "mish mash of old books and new books" and that they do not have a proper understanding of math and will not for another 8-10 years. Yet another concurred, stating that the degree of "rigour" they used to do before Math 1205 (the advanced math) is definitely more, and that if you compare math tests in high school from then and now, the tests are less rigorous now but whether they were better math students then is another question.

Some other opinions included that this is the first year that all students came from the APEF curriculum from primary school onwards, and that skills are weaker and work ethic is degraded. One particular participant thought students' behaviour and attitudes toward work have declined overall, perhaps reflecting societal changes over that period. In any event she felt the old Math 3201 had a much better success rate than the current courses. Another replied

in a similar vein regarding work ethic, commenting that students are not being taught to be independent learners and this deficiency affects all subject areas. One of the primary/elementary teachers acknowledged not being all that familiar with high school but did remark that the higher percentage of students graduating with basic diplomas as opposed to academic was a major cause of concern in her school. Another newer teacher thought having done the pilot program in high school put her at a disadvantage, and that she did not get the level of instruction she needed to enter university. She did express optimism, however, that the new program would make students better prepared in the future. Finally, another respondent thought the biggest problem was that the K-6 program prepares kids to be problem-solvers and thinkers, and then 7-12 focuses on tests and "spitting back the material they are given." Then, in her mind, the university wants them to revert back to thinking and problem-solving again. She explained it this way:

In Grade VI we get them creating mind maps and concept maps and thinking about things. Then, in Grade VII they are sitting there writing and memorizing notes. So I don't think we are preparing them. The teachers of Level I to III have really got to work on their learning styles.

4. 6. 7 Usefulness of Course Textbooks

Based on the responses to the question of how useful teachers find the math course textbooks, several themes emerged. Generally, respondents felt the texts based on the investigative approach (i.e., APEF) were very much lacking while the newer texts, some from the Western Protocol, were credited with being better resources and better matches to the course outcomes.

With regard to the former, one participant said the course texts using the investigative approach were "awful" with very few examples, requiring teachers to supplement the material through the internet and other sources. Another agreed, stating that supplementary workbooks like Todd Sharpe's book are needed to augment the text. For another, the change in approach was too dramatic and the resource textbooks needed more drill and practice rather than investigations which move quickly from one to another with very few notes and very few examples.

With regard to the newer texts, teachers reported a better match between the curriculum outcomes and the books with comments that the Grade V, Grades VII and VIII texts are "decent" and "fairly good" with much less supplementing required. Another noted that workbooks are such excellent tools especially for kids with organizational problems. Two other respondents stated

they do not personally use the textbooks much, but one felt the new texts will probably be written to better meet the outcomes, and the second agreed, commenting she liked the approach of the Western Protocol but from what she has seen, thought it might not always relate to the children of Newfoundland. She put it this way:

So doing a pow-wow, which is a great thing to learn about, might not really fit for Newfoundland children. But no resource is perfect. I would use the same concepts but put it in terms of dories and fishing or skiing or something in relation to Newfoundland.

4.7 Conclusions

4.7.1 Adequacy of the Math Program

When questioned on the adequacy of the math program, the respondents in the study were more or less split, with half leaning one way and half the other. Of those who thought it to be inadequate, one felt there was room for improvement because students are not being properly prepared for post-secondary education. Another concurred that the necessity of a math placement test indicates students might not be prepared for post-secondary or for entering the workforce. A third thought it could be adequate "but given the gaps and the

lack of resources and lack of in-service, I don't think it is, or is going to be." For another respondent, the biggest issue is that the students in the general program who do not have a high level of mathematics are doing topics like exponential regression and have no understanding of what they are doing. He felt that the new Western Protocol, from what he had seen, for the general student is much better, going back to the more practical side of math. He also commented that here we have students with nine years under a new math ideology switching again to the new Western Protocol and, not seeing that program in enough detail, he was unsure whether it would be adequate or not.

Of the teachers who felt more positive about the adequacy of the program, one said the new Grade VII course was excellent and hopefully a harbinger of things to come. Another also commented the Grade VII to IX program was an improvement since the curriculum was reduced and was more "do-able," and that the new books were also getting positive feedback. Still another thought it is fine in K-VI because it creates thinkers as long as it is done the way it should be done. Finally, one teacher stated that it was satisfactory but cautioned:

I feel that with the new math program, it's only as good as the teachers who are teaching it and teachers are only as good as the support they get.

Just because problem-solving is in the guide doesn't mean it's going to be in the classroom. So if the new program (WNCP) is implemented and done in the way it's supposed to be, I think it's going to be a good program.

4. 7. 2 Changes for Improvement in the Math Program

The question regarding recommendations for improvement provoked some interesting commentary in the interviews. One teacher was excited about the new Western Protocol as was another who felt, for the proper implementation of the program, the professional development and support needed to be provided in an appropriate and timely fashion, and he also endorsed and commended the numeracy support teachers (NST's) for the work they were doing. Another mentioned the importance of the implementation and stated that teachers need to be well-versed in the program and be given the opportunity to have input into it. He also felt resources was the key:

You've got to have resources on hand at all times. Now with technology, for example, the textbook should be on-line. That way, I can call the textbook up on the website, call it up on the board, and show the students

a diagram that's from the textbook. They got it in their hands in front of them and I'm pointing to it on the board.

Several other suggestions were made regarding curriculum. One was that it was crucial for students in elementary and junior high levels to obtain basic skills because if not, they are doomed to failure in the higher grades. Another commended the advanced Math 3201 with its supplementary course Math 3105 (the pre-calculus course), but generally felt there has been much lost from the curriculum, particularly geometry skills because much of it is omitted or neglected in Grades IX and X. Finally, another respondent stated that more attention should be given to different learning styles and we need to make math more project-based. She made this observation "Everyone is preparing these kids for university instead of preparing them for life and I think that's two different things."

4. 7. 3 The Controversy – A Look to the Future

Most of the comments regarding whether or not the controversy would be resolved were in the negative. One teacher felt math education was dictated by the politicians, which means there will never be much continuity in the

program. Another thought that people at the Department and Governmental levels need to listen to those at the lower end of the spectrum and teach what is "developmentally appropriate" at a pace that the children can understand. There was also the opinion that the drill and practice method remains the best approach if you teach the basis of the theory with background information and real life examples, and simply provide a good method that they can have success with and practice.

On a more positive note, one respondent thought and hoped that the controversy might be resolved if the new Western Protocol brings a discovery, problem-solving investigatory approach along with a drill and practice component. Another noted that you can bring in whatever curriculum you like, but it will not get any better until we start instilling a better work ethic down in the lower grades and teaching children more independence. With regard to the Western Protocol, one teacher remarked:

There is always going to be controversy in math. Comments have been made that the math world is starting to become quiet. I don't know if it's because the WNCP is new and is just being implemented. I like to think that things are going to be a whole lot better but things are never going to be perfect.

Finally, another respondent, too, felt the controversy would rage at least until her retirement. She commented, "If you don't have controversy, you don't have change. I think it's a good thing. There are always things there that you can change as you will. But we'll always be fighting over the issue."

4. 7. 4 Further Reflections

When asked if they would like to share anything further to explain their viewpoints on math reform, the respondents in the study delivered some very poignant remarks. One thought the focus needed to be more on Grades VII to Level III and to carry the "elementary perspective" forward because it is that approach that works with students and they can relate to it. Another reiterated that he was happy that the general program would be changed in accordance with the new Western Protocol, and that the new program, in general, will make students be better prepared as we move into the future. Two other participants thought the keys were: 1) to teach students responsibility and 2) to hold students accountable to work, listen in class, do homework and study and if they don't do their part, there isn't much we can do for them.

There were two opinions expressed at the end which could serve as counterpoints to the problem-solving, investigative approach vs. the drill and practice methodology. To support the latter, one respondent commented:

I believe that, for most of what we learn and do in life, automaticity is the key. Students need to foster ideas with regard to basic skills from Kindergarten onwards to be successful. The Asian education systems and even the Eastern European countries are outperforming us, and they are not doing the investigation type learning. There, it is drill and practice for fostering skills and it seems to be working.

In support of the math reform movement, a proponent offered these observations:

I'm a firm believer in [the investigative approach]. It works but it's a lot of hard work. The teachers are problem-solving, getting students to really understand what they are learning in math and why they are learning it – finding the real-life context because they need to use it outside of school. I'm going to continue to do what I'm doing because I know that it works and I see the progress and success of my students.

CHAPTER FIVE

DATA ANALYSIS

Back in the discussion of methodology (Chapter 3) there was a recognition that the main challenge of the researcher is to identify emerging themes and patterns from the interview data. At that time four categories were hypothesized to assist in both the development of the teacher protocols for the interviews and the subsequent coding of the data. The four categories can be aligned with the interview structure in this manner although there is considerable overlap:

- 1) role redefinition – reform and classroom management.
- 2) structural constraints – reform and evaluation.
- 3) professional development – teacher support.
- 4) educational stakeholders – stakeholders in reform.

After a brief analysis of the background, it is through this order and structure that the findings will be examined.

5.1 Background

As previously reported, teachers in this study unanimously felt that their working environment was very much impacted by math reform. The eight participants were generally very experienced (with a mean of 14 years) with three having degrees in mathematics and all others having a minor or a concentration in math. There was also good representation from Grade IV to Level III. Half felt they were more than adequately trained. Others felt that simple experience was the best teacher and that Master's courses and tutoring were beneficial in preparing them for success in the classroom. All felt that their own experience as students had influenced the way they teach, with several stating that these experiences were not positive.

5.2 Role Redefinition

The definition of the respondents' roles as math teachers is very much expressed in questions pertaining to classroom management. Despite the fact that there were many commonalities in their teaching styles – most of what they reported were simply sound teaching practices – there was a split between those who describe their style as an investigative or problem-solving approach and others who use the more traditional, “chalk and talk” method. This dichotomy

is reflected in most of the responses throughout the interviews although not with the degree of consistency that one might expect. In the AERC Final Report (2007) one of the main findings was that “the literature seems to support the idea that mathematics should be taught for conceptual understanding and that this does not interfere with basic skill development” (p. i).

With regard to accommodating individual learning styles, all respondents recognized that different students do have different learning styles as previously stated. A variety of strategies and resources were identified to accommodate the differences. Much of the dialogue dealt with students with learning difficulties and the challenges they present on both ends of the learning spectrum. The demands of having to finish the curriculum in a timely fashion as well as having such a wide range of advanced, academic and basic students in the same classes were mentioned as significant in reconciling individual learning styles and making necessary adaptations. For successful teaching, several factors were prominent in the minds of the participants including good student attendance, strong work ethic, confidence, having the pre-requisites, motivation, encouragement, and positive feedback as well as teachers knowing the needs of their students.

The questions pertaining to problem-solving vs. drill and practice have a lot to do with defining one's role in the light of math reform. When asked through which approach students experience more success, it has been noted that two chose problem-solving, four cited drill and practice and the remaining two endorsed a combination of the two. The strong support and adherence to drill and practice techniques, what Eisner (1994) calls "pouring from the big jug into the little mug" (p. 13) indicates that teachers are continuing to utilize the traditional mode in the classroom despite the prevalence of the problem-solving approach in the curriculum. Orrill and Anthony (2003), Battista (2001) and Huffman (2008) all expressed parallel concerns as referenced in Chapter 2. Teachers seem to be saying that they prefer the structured, "recipe" type methodology with its consistent practice and rules for learning and that while the discovery-style learning of the investigative approach has merit in the transferal of skills and developing strategies to solve problems, an entire math program should not be centered around it and that the two approaches are not conceptually incompatible. The AERC Final Report (2007) concluded that:

Although there is some support in principle for the conceptual/investigative approach to mathematics, there is strong evidence that teachers feel that the balance has shifted too far and that

students are progressing through the grades without having mastered basic skills needed as more advanced mathematics content is introduced.

(p. i)

Regarding long-term retention of skills, responses once again reflected the same dichotomy. Half of the respondents felt the problem-solving technique allowed for strategies to facilitate long-term retention, and made mathematics easier to understand and thereby, made it more meaningful. However, there were at least two participants who subscribed to the belief that practice is the key and that acronyms and mnemonic devices are more effective for students' long-term retention. Again, there was also the hybrid philosophy expressed that where math exploration and discovery promotes retention and understanding, so too does simply performing a task numerous times.

When asked whether it is difficult to meet curriculum outcomes, two respondents thought the problem-solving approach was superior because multiple outcomes could be addressed with one single problem and also that mathematics takes on "more relevance in a realistic world." Several others, however, replied that the new investigative approach takes much longer, that there are too many SCO's and that students lack the pre-requisite math skills to accommodate the discovery method. For them, the time frame for the courses

is too compacted and they cannot do justice to all the material required. From one respondent the message was you must by necessity find a balance between how much you investigate and how much you teach directly. Her formula for success was well-trained teachers with reasonable expectations in a sensible time frame.

The majority of the respondents do supplement the SCO's. Time restraints pre-empt some extensions of topics of interest and discussions. For one teacher, having to repeat investigations and re-teach topics often diminishes the possibility of enrichment. There was also the opinion that the SCO's are dictated and extensive and not a whole lot of supplementing was plausible or necessary. All respondents, however, identified some type of enrichment including extra work or teaching outcomes from higher levels or grades, often related to technology. Most participants also indicated some kind of extra-curricular activities like Math League competitions, math contests and special projects.

5. 2. 1 Role Redefinition and Math Reform

Roper and Carter (1994) addressed the importance of teachers' understanding the philosophy of reform and their mastery of the method of

instruction that it entails. Practically all respondents understood math reform to be a movement towards an investigative or discovery style of learning, as opposed to the traditional drill and practice model. Such terms as math exploration or the problem-solving approach were used to describe math reform, and that reform meant "rethinking" math and getting back to its roots. They also felt that the curriculum was reflecting this move. There was a sense, however, that many teachers may not be doing the investigations as prescribed, but were instead supplementing the material with workbooks. There was certainly the opinion that good practice resources and worked-out examples were lacking in many recent textbooks. One respondent described the shift as moving from a procedure knowledge base to a conceptual one, and she felt this provided a challenge to students to apply knowledge, thereby fostering greater understanding and connectivity. More than once the new Grade VII program was commended because it seems to incorporate investigative learning with direct teaching. These comments indicated that there were more resources in the program with practice materials and worked-out examples, something missing in other more recent textbooks.

As to whether math reform "works", there were divided opinions among respondents. There still seems to be strong support for drill and practice

methodology, and several participants who were positive on math reform do have reservations. For at least one teacher, the math reform approach presumes that students have the pre-requisites for their grade levels which is often not the case. Remember, several respondents felt that the implementation has been seriously flawed and proper and timely in-service has not been provided. The sense was that math reform has strong points in its favour and "rethinking" math is never a bad thing, but that many teachers do not have confidence in it and need to develop a "vested interest" in it. Other responses simply preferred organized, structured lesson plans and did not subscribe to that "higher end" approach to math exploration. Despite this, the majority indicated they supported math reform in general, albeit with some reservations. The fact that it gives students alternatives and the freedom to discover was lauded. However, the problems previously mentioned were very much emphasized along with concerns about efficient use of time and keeping students on task and also as previously stated, one teacher felt a combination of both investigation and drill and practice was her preferred *modus operandi*.

With respect to role redefinition, this study indicates that math teachers in general have not been willing or able to modify their practices in response to math reform. Practically half of the respondents reported that teachers have

indeed tried it and found it too difficult or time-consuming and have reverted back to more traditional teaching. One opinion is that teachers do not fully understand the problem-solving approach and another was that it has not been given a fair chance, while another more positive view was that teachers are incorporating investigations and drill and practice into their teaching as they always have.

5.3 Structural Constraints

Along with implications for the math teachers' definition of their roles comes structural constraints which impact their performance as teachers in reference to math reform. In other words, the shift into a problem-solving methodology involves teachers modifying their practices to meet reform expectations. As referenced in Chapter 3, Orrill and Anthony (2003) outlined numerous factors that contribute to why teachers of mathematics struggle with reform pedagogy. Although this issue is evident throughout many of the subtopics in the study, the obstacles related to time and evaluation are perhaps the most pronounced and therefore, the emphasis of this analysis will be placed on these factors.

All eight respondents thought the utilization of the math reform model placed more demands on their time. Generally, they thought getting materials and resources were very time-consuming and that the methodology itself was not always time-efficient. After all, as one respondent observed, teachers have to figure out the different possibilities that the students may discover – to “differentiate” the lessons – as well as cover the gaps in the students’ understanding. Overall the feeling was that better in-servicing and training, perhaps even a course offered to teachers, might alleviate some of these problems.

When queried about obstacles to meeting reform expectations, teachers identified students’ lack of ability and motivation, the need for more support and flawed course design along with the time constraints and insufficient in-servicing referred to above. There was the opinion that teachers simply have not been prepared for the new approach and were expected to change overnight. As Heaton (2000) observed, just as mathematics teaching has been redefined through reform, so too must methods to assist teachers be revisioned to include even the uncertain, spontaneous nature of teaching. The sense was that teachers revert back to algorithms that work in order to complete the courses and address the accountability issues.

5.3.1 Evaluating Student Performance

Formal and informal assessment, the determination of to what extent the SCO's have been achieved, is always an important consideration and is greatly influenced by a teacher's particular methodology. Several respondents stated that summative evaluation is generally laid out and dictated by the school district. For the most part, traditional tests and quizzes, projects, journal writing, observations, and homework checks comprised the gamut for assessment. It was recognized that there is a challenge to find alternate math assessments to paper and pencil methods.

The NCTM's landmark 1989 document, *Curriculum and Evaluation Standards for School Mathematics*, expressed parallel concerns when it calls for a "shift in assessment from serving as end-of-the-unit tests to assisting teachers in diagnosing and addressing students' strengths and weaknesses" (Loveless, 2001, p. 3).

For more informal assessment, observation, homework, anecdotal records, project work, portfolios and rubric charts were identified. It was noted that using the reform methodology would probably place greater emphasis on these means of assessment because of their more open-ended nature.

Interestingly, Schoenfeld (1988) stresses that virtually all standardized testing for arithmetic competency focuses primarily on procedural mastery. With regard specifically to homework, the majority of respondents stated homework was important, recommending something in the range of one half hour two to three times a week. There was no direct link in this study between prescribed amounts of homework and reform ideology.

Many opinions were expressed in this study with regard to testing and specifically, common tests. A significant number of respondents thought public exams are often "taught to the test" and their reasons are, of course, outlined in Chapter 4. An equal number, however, did not support teaching that way, choosing rather to treat the content as "an organic wholeness," more consistent with a reform approach. Structural constraints were acknowledged in this area, however, with the recognition that CRT's and public exam results raise accountability issues and most teachers seem to be teaching certain related skills and providing opportunities and activities which are conducive to positive results on these tests.

All the respondents in the study acknowledge the pressure to have students perform well on common exams. Many different reasons and scenarios were presented to account for this pressure and many variables and

factors were cited that affect results. The determination of responsibility for any particular results was described as a difficult endeavour, to say the least. While all respondents reported that they reviewed for common exams, the amount of time varied significantly.

When asked whether students today are better prepared for post-secondary education, the vast majority responded in the negative. The investigative approach was implicated in students performing worse in university courses because of a "mish-mash" of textbooks and a definite decrease in the amount of rigour that the courses require of the students. The AERC Final Report (2007) concurs that the adoption of the Atlantic Provinces framework and content has lead to reduced rigour in the mathematics curriculum in Newfoundland and Labrador. There was the opinion that skills are weaker since the APEF curriculum was adopted and that a higher percentage of students are graduating with "basic diplomas." In fairness, however, it was also proposed that students' behaviour and attitudes toward work have declined overall as well as their work ethic. With regard to course textbooks the APEF were described as very much lacking with few examples and requiring much supplementation. According to the AERC Final Report (2007), concerns over these textbooks are well founded and there is a "lack of

match between outcomes and textbooks and a perception that many of the prescribed texts are of poor quality" (p. 84). Several respondents wanted to see more drill and practice in the resource textbooks rather than simply investigations which move rapidly from one to another. Conversely, the approach of the Western Protocol was credited with being a better resource and a better match to the outcomes of the courses.

5.4 Professional Development

When this study was first conceived, it was recognized that the amount of support for teachers in enacting math reform may be a major area of concern, and this emphasis was reflected in the number and range of questions devoted to it in the interview process. The respondents had much to say about professional development and the support available to them in enacting reformist goals. While practically all the participants reported feeling competent teaching mathematics, they did not necessarily feel comfortable with the goals of reform.

On the subject of support, almost all teachers responded that support was either inadequate or inappropriate. The general finding was that confidence in the new ideology has taken a lot of time to develop and has come, for the most

part, through their own initiatives and efforts. There were complaints that they have not been shown how to utilize time effectively to handle the investigative approach, and that, if not for other teachers teaching the courses or the training from outside sources, there would be no support. The overall sense was that many teachers do not feel qualified to deal with reform and that the Department of Education must shoulder some of the responsibility in the way the program was implemented and the lack of in-service and support provided, including from the district level. As stated, most teachers in the study reported more assistance was definitely needed to successfully implement the new programs. Younghusband (2005) in her doctoral thesis *High School Teachers' Perceptions of Their Working Environment in Newfoundland* states, "Teachers do not feel that they have an equal partnership in education; they feel overworked and unsupported. They report being excluded from the decision-making process and they want some autonomy" (p. 11). More collaboration and the exchange of ideas as well as better resource sharing were suggested as possible remedies as well as more "hands on in-servicing" and smaller classes. Several respondents stated they were the ones giving help to others when in fact little assistance had been given to them.

On the subject of resources, teachers thought that, not only should adequate resources be provided, but that they should be given up front to all the course teachers in a timely fashion. As Roper and Carter (1994) point out, teachers must not simply be aware of the new material to be taught, but they also must understand and sympathize with the means by which it is to be taught and its underlying philosophy.

Younghusband (2005) also recognized the need for appropriate resources:

The implications of inadequate resources affect both teachers and students. This issue must be addressed at all levels of education, and teachers' concerns should be taken seriously to ensure that adequate resources are available. (p. 164)

Study participants felt that budgetary constraints are all too common in limiting these crucial resources. Not all responses were negative, however, on the subject of resource availability. The Eastern School District was applauded for providing some excellent materials and the new Grade VII program was praised for its textbook and supplementary resources.

The importance of math teachers creating their own resource bases was also emphasized. It is interesting to note that all eight respondents replied that

they used their own unique set of notes, old books, and other resources as supplementary materials. As one participant stated, you need these items to “tweak those things to your own style of teaching.” There was the sense though that some teachers were optimistic that the new courses in Grade VII, VIII, and IX at least will not need to depend as much on supplementary materials.

Teachers identified many useful resources however including a supplementary book by Todd Sharpe, Smart Boards and on-line sites, NCTM journals, including the Navigation Series, as well as the Centre for Distance Learning website (CDLI).

On the subject of professional development, almost all respondents were resoundingly critical of the amount and timing of in-services. The details of their commentary are outlined in Chapter 4 where the message that came through loud and clear was that the powers that be at the board and department level need to address this situation. There were some positive comments to indicate things may be changing for the better but the general sense was that the PD being mandated is still insufficient.

When asked for recommendations for improvement, the general response was that teachers need more in-service than is presently provided and it must be done before the curriculum is implemented. The need was expressed for more

professional collaboration and resource sharing among teachers, and that schools should do their best to facilitate these exchanges, especially for teachers new to the courses. By promoting such collegiality, many misunderstandings surrounding the problem-solving approach could be resolved and it might consequently be given, in at least one respondent's mind, a "fair chance at success."

5.5 Stakeholders

The nature of teaching is such that teachers do not work in isolation. Rather, they are part of a larger system and they impact and are impacted by other components of that system. Therefore, the beliefs and attitudes of parents, the Department of Education, and even other teachers are very influential in the way teachers generally deal with math reform. In terms of parents' attitudes, more than half the respondents thought that parents generally feel negative toward reform. It seems that parents are frustrated because the approach is new to them and they are at a loss to help their children with this discovery learning. In at least one teacher's opinion, parents do not know enough about math reform to support it or not support it but that they will eventually when they see their children "getting it." There was the sense that parents have not been

included to the extent that they should have been and that more effort needs to be made to facilitate a better connection between home and school.

The Department of Education was, of course, recognized as the principal player in the math reform movement. Despite comments that following the lead of the United States can be problematic and that leadership in the Department is transitory, there was the acknowledgement that the Department wants better students who can handle and apply problem-solving strategies. There was also the belief that the university is first and foremost in the drive for math reform for the same reason and that the Department is also very concerned with the low percentage of students actually passing academic math. This new direction by the Department had several endorsements in the study as teachers acknowledged that we are living in a more technological world – one where children and adults too, need to be able to solve problems – and the respondents felt that the new approach seems to get better results with regard to that goal.

There were definitely mixed reactions when respondents were asked about the Department of Education's response to teacher feedback. In the negative camp, teachers felt in-service was often so far behind that teachers' suggestions often could not be incorporated into curriculum and that often the changes they request are not addressed. There was also the complaint that in

the Atlantic Provinces curriculum courses, many suggested that their suggested modifications have been vetoed by the other provinces. It was also stated that media and parent pressures are the only forces which have any real and direct impact on Department policy.

On the positive side, the Western Protocol drew favourable responses and the comment that the Department is "getting the message" and responding to the concerns of teachers. The number of emails exchanged and amount of course discussions with opportunities for input and feedback were hailed as significant signs of movement in the right direction.

It is very interesting to note that almost all the respondents did not think teachers are responding well to math reform methodology. They generally thought it seems to be working for some but not for others, and that there are no checks and balances in place to monitor the new approach. For many respondents, the problems are related to implementation. Teachers are saying they are not getting enough direction on how to implement and present it. Consequently, students have problems with it, and teachers have a tendency to revert back to drill and practice methods. The sense is that the theory is not being translated well into practice and teachers are simply not used to teaching in accordance with reform ideology.

Half the respondents stated their courses would be affected by the Western Protocol in the coming year. The opinion was expressed that the method of implementation is a good indication that the Department wants to ensure that things are ready before the new protocol is operationalized. Despite this fact, almost all participants said there was no consultation with them before the decision was made to adopt the Western Protocol but there was also no dissension about the move either. They generally felt there was so much dissatisfaction with the current curriculum that any attempt to bridge the gap between investigative learning and drill and practice would have to be positive, and that the WNCP appears to be an excellent approach to teaching mathematics.

When queried on the implications of math reform on teachers, half the respondents felt math reform, and specifically the Western Protocol, will create extra workload for teachers. Dibbon (2004) studied the impact of workload on teachers and students and found that excessive workloads were prevalent in Newfoundland schools. It was mentioned too that such an increase is fairly typical when new courses or changes in curriculum are introduced, especially if the proper resources are not provided. The opinion was expressed as well that students may not have the academic ability or the pre-requisites for the courses

or may not get the supports they need to be successful. Several respondents, however, were optimistic that resources matching curriculum outcomes would be supplied which would ultimately lead to a decrease in workload.

With regard to teaching style, there was the sense that some teachers will continue to teach the way they always have, regardless of whatever the recommended approach may be. As well, there is the belief of at least one respondent who feels he has always incorporated the math reform ideology into his teaching. For others, the success of math reform depends on if the Department gives enough direction with more practical resources and more clarity with regard to curriculum expectations.

5.6 Further Reflections

It is interesting to note that when asked if the current math program is adequate, the respondents were more or less split in their opinions. On the negative side, there were the sentiments that students are not being properly prepared for post-secondary education and the program is characterized by too many gaps and too few resources and too little in-service for teachers. For another, it was simply that the general (practical) program has topics like exponential regression, and general students simply do not have a high enough

level of mathematical skill to comprehend such topics. On the positive side, the new Grade VII course was praised and the junior high courses generally as well for their reduced curriculum and better textbooks. Another felt the K-VI program does "create thinkers" if done the right way and there was also the caution that the math program is only as good as the teachers, and the teachers are only as good as the support they get.

When asked for suggestions on how to improve the current math program, there was considerable positive feedback on the Western Protocol. With proper implementation, professional development and support provided in a proper and timely fashion, they felt it could be very successful. There was also mention of the fact that teachers need to be well-versed in the program and be given the opportunity to have input into it and of course, the need for relevant resources was again emphasized. It was also stressed that math skill development in the elementary and junior high levels is so crucial for success in the higher grades.

As to whether the controversy over approaches to teaching mathematics will ever be resolved, most comments were in the negative, largely because they feel the Department lacks continuity and is not as in tune with those at the lower end of the spectrum as they need to be. There was hope, however, that

the Western Protocol may bring some resolution if it incorporates elements of discovery learning with drill and practice but issues related to student work ethic and overdependence will probably persist.

CHAPTER SIX

CONCLUSION

6.1 Synopsis of the Study

Before a discussion of the implications of this study, a synopsis of the salient points made by its respondents is warranted:

6.1.1 Math Reform

Practically all respondents reported a thorough understanding of what math reform entails. They used vocabulary to describe it like the following: "investigative" or "discovery" style of learning, "math exploration" and a "problem-solving" approach. The majority of participants described their teaching style as using the problem-solving approach while several admitted to being more traditional. Several respondents expressed concerns that many teachers do not know about math reform and observed that the problem-solving approach has not been given a "fair chance."

As to whether math reform works and if they support it, two stated drill and practice works better, two preferred the reform approach, and four were positive toward reform but had many reservations. Those with concerns

reported problems with implementation, in-servicing, and students lacking prerequisite skills as well as having poor adaptability for higher level learning.

All felt the math reform model placed more demands on their time, especially with regard to getting materials and resources for investigations. Obstacles mentioned to meeting reform expectations were related to time constraints, students' lack of ability and motivation, too little support, flawed course design and insufficient and untimely in-servicing. When asked whether students experience more success with the problem-solving approach or using drill and practice, study participants were divided – two chose the former, four the latter and two endorsed a combination of both.

6. 1. 2 Teaching/Learning Styles

All recognized that different individuals have different learning styles, and all reported using strategies to help students with learning challenges on both ends of the ability spectrum. Teachers identified many factors that pertain to successful teaching including good attendance, work ethic, building confidence, motivation, positive feedback and goal-setting. Several recognized the necessity of whole group teaching but they did acknowledge its limitations

especially in keeping students' attention. Despite an emphasis on small group work, all felt independent seat work to be critical for student success.

For long-term retention of skills, the respondents replied half in favour of problem-solving and half for drill and practice. Regarding meeting curriculum outcomes, two thought SCO's could readily be met using the problem-solving approach, three preferred drill and practice as being more effective and three had mixed feelings on the subject. Practically all study participants reported that they use supplementary materials including their own unique sets of notes, old textbooks and workbooks.

6. 1. 3 Professional Development/Resources

Almost all respondents were critical of the amount and timing of professional development and felt more collegial collaboration and resource sharing should be happening. Textbooks based on the investigative approach (i.e., APEF) were described as sadly lacking by study participants and requiring much augmentation.

6. 1. 4 Stakeholders

Regarding stakeholders in reform, the majority noted that parents have a negative attitude towards reform, characterized by ignorance and frustration. They also felt that the Department's intentions may have been well directed but the implementation was flawed and that in at least half of the opinions expressed, the Department does not respond adequately to feedback from teachers.

6. 1. 5 Current Mathematics Program

On whether or not the current mathematics program is adequate, the responses were more or less split halfway, with lack of resources and inadequate in-service cited as the biggest deficiencies. There was a much more favourable response to the Western Protocol and the Department was lauded for its support of and movement toward the WNCP curriculum.

6. 2 Recommendations

Although this research is interspersed with recommendations by the study participants throughout Chapter 4 (Data Presentation) and Chapter 5

(Data Analysis), there are some of both a general and specific nature which deserve emphasis and which possibly should be explored and implemented.

Professional Development

In-service should be provided in sufficient quantity and in a timely fashion, before new courses begin and especially to teachers new to courses. For WNCN Protocol, levels of PD should be consistent with our counterparts in the Western Provinces and Northern Territories. Better DVDs of best practice should be developed as a form of in-service and teachers should be given sufficient time to view them. Teachers should be paid to do PD during summer institutes.

Resources

Teachers should be supplied with a copy of all course resources and materials including those for pilot courses. Courses should be implemented only after all the necessary preparation has been completed. Practice materials and worked-out examples should be available to teachers for relevant courses. A NCTM website membership should be purchased for all teachers.

Department of Education

The Department of Education should provide direction with exemplary models and the time for teachers to make adjustments to curriculum. A reduction in the number of SCO's in mathematics courses was recommended. The Department should also request and action more recommendations from teachers at workshops. More itinerant math teachers should be hired as well as more math specialists to focus particularly on lower grades. Department heads in school should be encouraged to take a lead role "providing checks and balances" on course implementation and progress. Student work ethic along cultural lines should be investigated to determine unique traits in student populations which may influence curriculum. Finally, with the implementation of the Western Protocol, it was advised not to try to do too much too soon.

Students

It was suggested that teachers need to be allowed a time factor to teach pre-requisite knowledge to students in courses where it is warranted. The Department could commission a survey/study of students' perceptions of the current curriculum and consider introducing a new junior high course on study

and time management skills. Schools should provide more extracurricular activities in mathematics (especially in rural areas) like mathematics leagues for lower grades.

Parents

It was acknowledged that better public relations need to be developed between parents and the Department and school boards. Possibly, courses could be provided to parents who wish to develop a better understanding of school life in general and mathematics in particular.

University

The university could ensure that pre-service mathematics teachers graduating from the Faculty of Education have relevant theoretical and practical knowledge regarding lesson planning, assessment strategies, including test design, and working with curriculum guides, and supporting documents. University personnel affiliated with Department of Mathematics and Statistics should review the high school mathematics program to ensure continuity with their first-year math courses.

6.3 Limitations of the Study

This qualitative study on math reform is based on a sample of mathematics teachers in the Eastern School District of Newfoundland. It is representative of male and female teachers in rural and urban schools on elementary, junior and high school levels. The ages of participants range from 24-51 and of the number of schools where they have taught, three is the most typical. Three respondents have Master of Education degrees completed or near completion.

The small sample size ($N = 8$) may be considered a limitation in this study. However, as previously mentioned, I felt the saturation point was reached at six interviews with no new major themes appearing after that stage. My research, however, may be somewhat limited in generalizability. Teacher perceptions and attitudes will likely vary from one location to another and even from one school to another.

My research focused on the meanings of experiences and situations as constructed by mathematics teachers, their perceptions of and attitudes toward reform. I hereby acknowledge a limitation that I was not concerned for the

most part with the “meanings” of reform for the reformers themselves, for students and parents, for administrators, and for other educational stakeholders.

It should be noted that the study has been approved by the ICEHR as well as the Eastern School District. Participants were duly aware that they could withdraw from the study at any time without penalty. Only teachers who have been significantly impacted by reformist mathematics were recruited for the study, meaning that they would have to be teaching for at least three years.

It should be acknowledged that the study may have primarily attracted teachers with strong opinions on reform. It is also possible that my own assumptions and biases have contaminated the data to some extent, although I have made every effort to place them in abeyance.

6. 4 Implications with Relevance to Other Studies

As Boaler (2002) notes in the introduction to her book, *Experiencing School Mathematics*, the question of which approach we should employ to teach mathematics in schools is one that has perplexed stakeholders for decades. The general acknowledgement that the teaching of mathematics is moving away from the traditional drill and practice approach and towards a more investigative, problem-solving style of instruction prompted this research

study. The AERC Final Report (2007) is the definitive statement on the current state of the mathematics curriculum in Newfoundland and Labrador. Many of the results of this study are consistent with the AERC findings as indicated by the previous references to the report. AERC explains the theoretical perspectives at issue this way:

The fundamental contrast between learning through practice and learning through a search for meaning persists, and remains the basis for much of the controversy in mathematics teaching and learning. This is evidenced by the continual tension between those who advocate a "back to basics" approach to mathematics curriculum and those who advocate teaching the underlying meaning for mathematical concepts and operations. Related to this is the tension between rote and discovery learning and between teaching as transmission of knowledge and teaching as facilitating learning. These tensions are found not only among professionals in the field but are evident in the public debate we are witnessing locally, nationally, and internationally. (p. 10)

There is a pedagogical shift which is reflected in the current curriculum, and the question is, how are math teachers adjusting and adapting to the

change? Where are Newfoundland schools in the process of realizing the movement toward the reform paradigm in the math classroom?

6.5 A Discussion of the Research Questions

In this section I summarize my findings regarding the research questions stated in Section 1.4. It is through this discussion that the study's insights and contributions to the larger body of knowledge are presented.

Question 1: How have math teachers adapted to changes in the curriculum? Have they modified their practice?

Teachers in the study felt unanimously that their working environment was very much impacted by math reform. It appears some teachers have made efforts to accommodate the new curriculum while others have persisted with or reverted back to more traditional methodology. Even among the stronger supporters of math reform, there was the opinion that it has not been implemented in an appropriate manner. There is the feeling it has not translated well into practice and that there are few checks and balances in place to monitor the new approach.

The general opinion from the study is that teachers as a whole have not been able or willing to modify their practices in response to math reform.

Several respondents stated that teachers have tried it but found it too difficult or time-consuming and have reverted back to drill and practice because it was more conducive to better performance and accountability. They are very much caught up in the dilemma described by the AERC Final Report:

Problem-solving as an approach to teaching and learning is seen by its advocates as a requirement for developing meaning and by its critics as detracting from the drill and practice required for children to master basic mathematical skills. (p. 11)

This is not to say there were no positive points expressed regarding the discovery model of instruction. There was a general endorsement of the merits of investigative learning but there was also a recognition of the need for direct teaching in many contexts. The importance of available resources with relevant practice materials and worked-out examples, so vital to good effective teaching in many of the study participants' minds, was constantly stressed as sadly lacking in much of the curriculum based on reform ideology, particularly of the APEF courses.

With regard to teaching style, there was the sense that some teachers will continue to teach the way they always have, regardless of the recommended

approach. There was also the observation that change will come only when the Department gives enough direction, provides exemplary models, and allows the time to make the adjustments. With this in mind, we can appreciate the importance of further qualitative studies to better understand how the reform movement in mathematics can best be addressed.

Question 2: What kinds of obstacles do teachers perceive in meeting reform expectations? To what extent do they feel supported in implementing the goals of reform?

Why have these respondents and math teachers generally been struggling with reform? The primary obstacles to meeting reform expectations involved time constraints, students' lack of ability and motivation, lack of support, flawed course design, and insufficient in-servicing (See Section 4. 3. 4).

Teachers expressed a lack of support on a number of different levels. Almost all teachers responded that support was either inadequate or inappropriate. They felt the actual courses were not laid out well with a poor match between curriculum guides and textbooks. Several participants stated that confidence in the new ideology takes a period of time to develop, and for them, it has come mostly through their own initiatives and efforts. One teacher stated she had not been shown how to utilize her time for the new approach and

that there simply has not been enough in-service or support from the Department or District levels to clarify expectations and provide resources.

Many of the factors identified in this study are consistent with professional literature on the subject. The major categories explored in the study all provide valuable relevant information. Teachers are being asked "from the outside" to change traditional methodology and in some respects to yield their customary seat of authority. They are asked to master new materials with inadequate professional development and a paucity of available resources. They are beset with structural constraints in school culture, requiring more support from their math departments and administrations than they have been receiving to deal effectively with these issues. It seems teachers are also more conventional with regard to assessment and classroom dynamics which are inconsistent with reform ideology. Finally, there are other stakeholders, like parents for example, who provide additional challenges to teachers in that they do not seem to understand or support math reform.

Question 3: Do teachers feel qualified and confident in enacting reformist goals in terms of the subject matter (mathematics) and pedagogical competence? Are teachers lacking in mathematical knowledge or classroom

management skills, or both with regard to the implementation of the new reform philosophy?

When asked whether they were adequately prepared to teach mathematics through their training, participants' opinions were divided as previously stated. However, most felt they had compensated for any deficiencies mostly through experience. I sense that they generally thought themselves to be competent and confident with the subject matter. They certainly demonstrated a thorough knowledge of what math reform was about. Despite this fact, some felt that a lot of teachers do not know about reform or misunderstand the problem-solving approach.

With regard to pedagogical issues such as classroom management, the respondents stated that the reform approach does require a shift to a different style of teaching. As Heaton (2000) explained, the movement from rote memorization and mechanical answer-finding to reasoning and problem-solving involves a major adjustment, particularly from teachers who have been conditioned to believe themselves to be the experts with a heavily prescribed curriculum. Trying to create the concept connections in "mathematical communities" that the reform approach demands, is certainly a daunting task for many and the participants identify those problems.

The teachers in this study do seem to feel, however, that many of their concerns would have been better addressed if the new approach had been given a fair chance. There was the recognition in many responses though that investigative learning is not necessarily a better approach and a great deal of support is still prevalent for the drill and practice methodology or at least a combination of the two styles of instruction.

Question 4: What are teachers' attitudes towards opportunities for professional development? Do they feel they have enough assistance in teaching according to a new approach? Do they believe they need more explicit and helpful guidance in meeting reform goals?

Almost all participants were critical of the amount and/or timing of professional development. One major problem identified was that PD was often done after the actual implementation of the courses when teachers were "knee deep in the curriculum." Many respondents thought that more inservicing, more professional collaboration and resource sharing should be happening. Others felt the Department should provide more practical resources and more direction and clarity with regard to curriculum expectations. The concern was also expressed that we need to keep pace with the amount of in-

servicing and support provided in the Western provinces if we adapt the Western Protocol.

Practically all respondents replied that students today are not better prepared for post-secondary education than in the past, and the reform approach was implicated for at least some of the blame. Regarding recommendations for improvement, the new Western Protocol was heavily endorsed but only if there is proper implementation, with professional development and support provided in an appropriate and timely fashion.

Despite not being consulted on the decision to adopt the Western Protocol, study participants reported being very supportive of the decision. They feel it may give rise to a workable hybrid of the problem-solving approach and the traditional methodology especially if it includes better, more user-friendly resources. Once again, from the AERC Final Report, it is important to note that "curriculum change that would take place under the recommended approach is not intended to tip the scale back to a purely procedural or algorithmic approach to mathematics" (p. 92).

It can not be stressed enough that teachers are at the heart of educational change and it is they who must operationalize any new approach and make it practicable. As Eisner (1994) points out, the school must be a growth

environment for the teacher if it is to also be an optimal growth environment for the student. The AERC also notes that, "Improvement requires change. While change may be engendered by high level policies, none of these policies is of any use unless something happens at the level of the teacher and the student (p. 13)."

The objectives of this study were to increase our understanding of the impact of math reform on Newfoundland teachers in their working environment, to learn the factors that affect its implementation, and just how comfortable teachers are with the process. These objectives have been met, and the results will contribute to further work on this very controversial subject. This research is significant because it extensively contributes to the literature by providing empirical research for an under-researched context, that being Newfoundland and Labrador. Further research could focus on a single aspect of mathematics reform such as its role in professional development, its implications for student evaluation, or its meaning for the specific stakeholders in reform. Certainly subsequent research into the impact of the WNCP protocols would be invaluable to determine how mathematics teachers have changed their beliefs and attitudes after implementation in the mathematics curriculum.

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APPENDIX A

District Letter: Request for Permission to Conduct Research

2 Tooton Place
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November 2, 2009

Dr. Albert Trask
Assistant Director
Eastern School District
Suite 601 Atlantic Place
215 Water Street
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Dear Dr. Trask:

I am completing my Master's in Education (Curriculum, Teaching and Learning Studies) from Memorial University, and I am currently working on my thesis. I am employed by the Eastern School District as a mathematics/social studies teacher at Baltimore School in Ferryland. In my capacity as a graduate student, I wish to invite the Eastern School District to participate in my qualitative study entitled: *Mathematics Teachers' Attitudes Toward and Perceptions of Mathematics Reform*.

The purpose of my study is to determine and describe mathematics teachers' attitudes toward and perceptions of mathematic reform. To carry out this study, I will need to interview (for approximately one hour) between five and ten mathematics teachers within the Eastern School District. These data will richly add to this research study and will be held in the strictest of confidence.

In my report, the names of the participants will be referred to by pseudonyms. In addition, teachers will not be identified by their school affiliation, but rather simply as mathematics teachers.

A transcriber and I will transcribe the interviews. We will comply with the TCPS guidelines for ethical research. The raw data, in the form of the recorded interviews and the corresponding transcribed documents, will not be heard or seen by other participants or anyone except the researcher, transcriber, and my academic supervisor, each of whom will adhere to the ethical guidelines outlined in this document. The data file for this research will be stored in a secure location.

Participation in this study is voluntary, and a participant is free to withdraw at any time. The proposal for this research has been received by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's Ethics Policy. If participants have ethical concerns about the research (such as the way they have been treated or their rights as participants), they may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 737-8368.

Should you wish further information on this study, do not hesitate to contact me or my thesis supervisor, Dr. Margo Kondratieva, Faculty of Education (709) 737-8074, mkondra@mun.ca.

Please find enclosed the following:

1. Eastern School District Application for Permission to Conduct Research
2. School Principal Letter
3. Participant Consent and Disclosure Form
4. Interdisciplinary Committee on Ethics in Human Research Approval

Thank you very much for your attention and consideration of this research project.

Sincerely yours,

David Matchem

(709) 747-3283 (h)

(709) 432-2090 (w)

dmatchem@warp.nfld.net

APPENDIX B

School Principal Letter: Request for Permission to Conduct Research

2 Tooton Place
St. John's, NL
A1E 4G8

October 2, 2009

Principal
Eastern School District

Dear M _____:

I am completing my Master's in Education (Curriculum, Teaching and Learning Studies) from Memorial University, and I am currently working on my thesis. I am employed by the Eastern School District as a mathematics/social studies teacher at Baltimore School in Ferryland. In my capacity as a graduate student, I wish to invite the Eastern School District to participate in my qualitative study entitled: *Mathematics Teachers' Attitudes Toward and Perceptions of Mathematics Reform*.

The purpose of my study is to determine and describe mathematics teachers' attitudes toward and perceptions of mathematic reform. To carry out this study, I will need to interview between five and ten mathematics teachers within the Eastern School District. These data will richly add to this research study and will be held in the strictest of confidence.

In my report, the names of the participants will be referred to by pseudonyms. In addition, teachers will not be identified by their school affiliation, but rather simply as mathematics teachers. In order to ensure confidentiality, please note that participants may or may not be selected from your school. In other words, if you provide your school's permission for me to conduct research, it does not necessarily mean that your school will be involved in the study.

A transcriber and I will transcribe the interviews. We will comply with the TCPS guidelines for ethical research. The raw data, in the form of the recorded interviews and the corresponding transcribed documents, will not be heard or seen by other participants or anyone except the researcher, transcriber, and my academic supervisor, each of whom will adhere to the ethical guidelines outlined in this document. The data file for this research will be stored in a secure location.

Participation in this study is voluntary, and a participant is free to withdraw at any time. The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If participants have ethical concerns about the research (such as the way they have been treated or their rights as participants), they may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 737-8368.

Should you wish further information on this study, do not hesitate to contact me or my thesis supervisor, Dr. Margo Kondratieva, Faculty of Education (709) 737-8074, mkondra@mun.ca.

Please find enclosed the following:

1. Eastern School District Approval for Permission to Conduct Research
2. School Principal Letter
3. Participant Consent and Disclosure Form
4. Interdisciplinary Committee on Ethics in Human Research Approval

Thank you very much for your attention and consideration of this research project.

Sincerely yours,

David Matchem

(709) 747-3283 (h)

(709) 432-2090 (w)

dmatchem@warp.nfld.net

APPENDIX C

CONSENT FORM

Title: Mathematics Teachers' Attitudes Toward and Perceptions of Mathematics Reform.

Researcher:

David Matchem
M. Ed. Candidate
2 Tooton Place
St. John's, NL A1E 4G8
(709) 747-3283

Research Supervisor:

Dr. Margo Kondratieva
Faculty of Education, MUN
mkondra@mun.ca
(709)737-8074

You are invited to take part in a research project entitled "*Mathematics Teachers' Attitudes Toward and Perceptions of Mathematics.*"

This form is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any other information given to you by the researcher.

It is entirely up to you to decide whether to take part in this research. If you choose not to take part in the research or if you decide to withdraw from the research once it has started, there will be no negative consequences for you now or in the future. Participation is independent of your employment and a

decision not to participate or to withdraw from the study will in no way affect your employment.

Introduction:

My study involves the investigation of teachers' perceptions and attitudes toward delivering the mathematics curriculum, particularly in the context of changes brought about by reformist efforts.

Purpose of the Study:

To describe Mathematics Teachers' Attitudes Toward and Perceptions of Mathematics Reform.

What you will do in this study:

The study will involve, on your part, one interview at a time and place to be mutually agreed upon. The interview, approximately one hour, will deal with your experiences as a mathematics teacher. The interview will be tape-recorded and later transcribed by a third party, with all items being stored in a secure location. I will use this interview as part of my thesis submission.

Possible Benefits:

While there are no immediate benefits, participation in this study may provide the opportunity for the participants to personally reflect on areas of practice and promote constructive professional dialogue.

Possible Risks:

I am unaware of any risks that you will personally experience as a result of this study.

Confidentiality and Anonymity:

Only I, David Matchem, the transcriber, and my university supervisors will have access to the tape-recording and transcription of your interview. Your name, however, will only be known to me. In other words, I, David Matchem,

will be the only person who knows you to be a participant. The signing of this consent form gives your permission to be included as part of this qualitative research study.

Recording of Data:

The study will involve the participant to be tape-recorded. The participant agrees to be tape-recorded.

Participant

Reporting of Results:

This interview will be used as part of my thesis submission. In my report, when using any participant's quotations, whether direct or summarized, the participants will be referred to by pseudonyms.

Questions:

You are welcome to ask questions at any time during your participation in this research. If you would like more information about this study, please contact the researcher, the research supervisor, the chairperson of the ICEHR or The Faculty of Education (Graduate Programs) at 737-3402.

Consent:

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 737-8368.

Your signature on this form means that:

- You have read the information about the research.

- You have been able to ask questions about this study.
- You are satisfied with the answers to all of your questions.
- You understand what the study is about and what you will be doing.
- You understand that you are free to withdraw from the study at any time, without having to give reason, and that doing so will not affect you now or in the future.

If you sign this form, you do not give up your legal rights, and do not release the researchers from their professional responsibilities.

The researcher will give you a copy of this form for your records.

Your Signature:

I have read and understood the description provided. I have had an opportunity to ask questions and my questions have been answered. I consent to participate in the research project, understanding that I may withdraw my consent at any time. A copy of this Consent Form has been given to me for my records.

Signature of participant

Date

Researcher's Signature:

I have explained this study to the best of my ability. I have invited questions and given answers. I believe that the participant fully understands what is involved in being a part of the study, any potential risks of the study and that he or she has freely chosen to be in the study.

Signature of investigator

Date

Telephone number: _____

E-mail address: _____

APPENDIX D

MATH FORUM ADVERTISEMENT

Subject: Request for volunteers to participate in a qualitative research study involving mathematics teachers.

David Matchem, M.Ed. candidate at MUN, is conducting a qualitative research study entitled: *Mathematics Teachers' Attitudes Toward and Perceptions of Mathematics Reform*. I wish to invite mathematics teachers from the Eastern School District to participate in my research.

The purpose of my study is to determine and describe mathematics teachers' attitudes toward and perceptions of mathematic reform. To carry out this study, I will need to interview between five and ten mathematics teachers within the Eastern School District. These data will richly add to this research study and will be held in the strictest of confidence.

In my report, the names of the participants will be referred to by pseudonyms. In addition, teachers will not be identified by their school affiliation, but rather as mathematics teachers.

If you are interested in participating, please contact:

David Matchem

Tel: 709-747-3283

e-mail: dmatchem@warp.nfld.net

APPENDIX E

INTERVIEW PROTOCOLS

Background

- How much teaching experience do you have? In how many schools have you taught?
- Do you have a degree in mathematics? If not, what training do you have in mathematics?
- What grades do you presently teach?
- Do you think your training has adequately taught you to teach mathematics?
- Has your own experience as a student influenced the way you teach mathematics?
- Is there anything else you could tell me about your career pathway?

Classroom Management

- Tell me about your style of teaching. How do you conduct a typical class?
- What do you do to accommodate individual learning styles?
- What do you feel leads to success with your students? What causes students to be unsuccessful? Can you relate specific examples?
- Do you feel students have more success with problem-solving tasks vs. drill and practice? Can you give some examples?
- Do you feel that students have more long-term retention of skills using the problem solving technique versus drill and practice?
- Do you find it difficult to meet current curriculum outcomes? Why?
- Based on individual student interests, if the situation dictates, are you able to supplement the course SCO's?
- What enrichment activities do you provide for students who excel in mathematics?
- Do your students partake in any extra-curricular activities in mathematics ie. Math league, math contests at MUN (in NL) and University of Waterloo (country-wide)?

Reform

- Tell me what you understand math reform to be.
- Do you think the reform method works? Why?
- Would you say you support math reform?
- Do you feel following the math reform model requires more demands on your time?
- What obstacles do you perceive in meeting reform expectations?
- How do you feel teachers have modified their practice in response to math reform?

Teacher Support

- Do you feel competent/supported and confident in enacting reformist goals?
- Do you get enough assistance in teaching according to a new approach? What can be done to improve this situation?
- Do you have adequate access to relevant resources?
- Do you use your own notes, old books or other resources as supplementary materials?
- Are you familiar with any useful resources that you feel other teachers may not be aware of? Why is it significant?
- Do you feel you have been getting adequate professional development, i.e. in-service, summer institutes, forum discussions? Is such PD being offered before the courses are introduced?
- What professional development improvements would you support?

Stakeholders

- Do you feel parents support the math reform ideology?
- Why would the Department of Education support math reform?
- Have you piloted any courses for the Department of Education in relation to math reform?
- Do you feel the Department of Education responds to feedback provided by teachers in such matters?
- Do you think teachers are responding well to math reform methods?
- Do you teach any courses that are affected by the current decision to adopt the "Western Protocol?"
- To what degree were you consulted about this matter?

- Does this decision have any implications for you as a teacher i.e. changes in your workload or style of teaching?

Evaluation

- How do you assess performance in your math courses?
- How important is homework, in your opinion? How much time do you feel an average student should spend at homework?
- Do you think math courses are too often taught "to the test?"
- Do you feel pressured to have your students perform well on common tests?
- Do you spend an inordinate amount of time preparing students for common exams i.e. public exams?
- Are students better prepared for post-secondary education today than in the past?
- How useful do you find the course textbooks with regard to meeting the course outcomes?

Conclusions

- Do you think, in general, that the math program is adequate? Explain.
- What changes do you recommend for improvement?
- What about the future? Do you see the controversy being resolved?
- Is there anything else you would like to share to further explain your viewpoint on math reform?

