

**A Qualitative Study of the Assessment Practices of Four Nova Scotia Grade 12  
Mathematics Teachers**

C. David Pilmer

Mount Saint Vincent University

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## Abstract

In 2003, a qualitative research project was initiated to examine the assessment practices of four Nova Scotian Grade 12 mathematics teachers. The participants were identified by a former mathematics consultant based on their ongoing professional development, and their willingness to use teaching practices, assessment practices and curriculum endorsed by the Nova Scotia Department of Education. Data from each participant was collected during a 1.5 hour interview focussing on the types of assessment practices each participant was familiar with, the rationale for using some assessment techniques and abandoning others, and the factors that influenced changes in their assessment practices over their careers. Questions regarding the participant's conception of mathematics and teaching practices were asked in order to determine if there was a correlation with the assessment practices that they used. The data revealed that the participants had extensive knowledge of assessment and used a wide variety of assessment techniques. For three of the four participants, there was a strong correlation between their conceptions of mathematics, teacher practices and assessment practices. Further analysis of the participants' interviews identified three broad, yet common, themes. The first theme addressed the unique and innovative alternate assessment practices used by the participants. These included pair quizzes and assignments, independent study projects, cafeteria testing and reflective self-assessment prior to a test. The second theme focused on participant concern regarding the direct and indirect influence of Board and Departmental policies on assessment practices. Policies that created time constraints within the classroom or altered the definition of authentic assessment were discussed by each of the participants. The third theme centred on techniques for exposing teachers to a greater number of varied assessment techniques through long termed sustained professional development and greater teacher dialogue.

## CHAPTER 1

### Introduction

#### *Contextualizing the Research*

In 2003/2004 school year, results from standardized tests and provincial exams were being reported in the media and in various Nova Scotia Department of Education documents. The poor results became a topic of interest in the media and with educators throughout the province, and brought the issue of assessment into the forefront. Journalists conducted interviews with parents, students, teachers, politicians, and representatives of the Nova Scotia Department of Education in an attempt to understand the source or sources of the problem. Based on these reports and personal discussions with colleagues and professors, numerous reasons for the poor exam results have been offered. These reasons include:

- large class sizes (30 or more students)
- poor student attitudes and work ethics
- retention and generous promotion policies in earlier grades
- lack of availability of teachers specialized in mathematics education at all grade levels
- effects of semestering on the teaching of mathematics
- fairness of the external exam
- teacher acceptance or resistance to the new curriculum,
- the quality of the student resource being used,
- unrealistic timelines to meet the outcomes,
- teachers' assessment practices,
- lack of long term sustained professional development for teachers
- exam exemption policies at some schools
- effects of Individualized Program Planning (I.P.P.) on the teaching of mathematics

No research has been conducted, however, to substantiate any of the claims. It should be noted that many of these potential sources deal directly or indirectly with the issue of assessment.

*Historical Background of Curriculum Development in Mathematics in Nova Scotia*

In 1989, the National Council of Teachers of Mathematics (NCTM) released a document *Curriculum and Evaluation Standards for School Mathematics*. This document was based on years of research from numerous sources and became one of the major factors driving change in the teaching of mathematics throughout North America (Lesh & Lamon, 1992, Peressini, 1997, Philipp, Flores & Sowder, 1994, Shannon & Zawojewski, 1995, Wilson, 1994) . It set new goals for students in an attempt to make them mathematically literate.

The Standards articulate five principle goals for all students:

- (1) that they learn to value mathematics,
- (2) that they become confident in their ability to do mathematics,
- (3) that they become mathematical problem-solvers,
- (4) that they learn to communicate mathematically, and
- (5) that they learn to reason mathematically.

(NCTM, 1989, p. 5)

From the teacher's perspective, this was to be accomplished by presenting students with novel thought-provoking problems in a setting which:

- (1) encourages group and class discussions,
- (2) recognizes that mistakes are an important part of the learning process,
- (3) encourages the use of manipulatives and technology,
- (4) endorses multiple strategies and sometimes multiple solutions, and
- (5) allows students to construct their own meaning of the mathematics so that they can ultimately make sense of mathematics.

(NCTM, 1989)

The intent is that students who have been exposed to a curriculum which adheres to these practices will be better prepared to think, learn, and adapt continuously in the very fluid Information Age (AECT, 2000, NCTM 1989, 2000).

In 1994, the Maritime Provinces Education Foundation (MPEF) was formed. Part of its agenda was to develop a common mathematics curriculum for the three Maritime provinces that reflected the changes endorsed by the NCTM. Newfoundland later joined the project and a new name was given to the foundation; the Atlantic Provinces Education Foundation (APEF). Prince Edward Island later pulled out of the project, preferring to develop its own curriculum.

Over a span of seven years, the remaining partners created a common mathematics curriculum at the secondary level that was heavily influenced by the reform approach to mathematics teaching endorsed by the NCTM. The new APEF mathematics curriculum and the accompanying student resources were designed to show students that mathematics is “a vibrant and useful tool for helping them understand their world” (NSDE, 2000, p. 6), and that mathematics encourages the use of “multiple strategies, student innovation and quite often multiple solutions.” (NSDE, 2000, p. 6) This curriculum emphasizes three specific student requirements:

- (1) Students should explore and experience authentic sense-making aspects of mathematics and learn to balance the acquisition of procedural skills with attaining conceptual understanding.
- (2) Students should actively participate in discussions where conjectures, reasoning, strategies, errors, and solutions are raised.
- (3) Students need to be exposed to routine and non-routine problems, which also may integrate mathematics with other disciplines.

This dynamic, creative, and sense-making view of mathematics is in stark contrast to the view held by some students that mathematics is merely a set of “concepts and algorithms for the teacher to transmit to students.” (NSDE, 2000, p.6)

As implied in the previous paragraph, mathematics under this new curriculum is to be taught using a discovery approach where:

classroom activities and student assignments must be structured so as to provide opportunities for students to communicate mathematically; via teacher encouragement and questioning, students must explain and clarify their mathematical reasoning; and mathematics with which students are involved on a day-to-day basis must be connected to other mathematics, other disciplines, and/or the world around them. (NSDE, 2000, p.4)

This approach to mathematics is designed to make mathematics meaningful and accessible to all students, addressing their wide range of individual learning needs.

The Department of Education recognized that assessment and evaluation were integral components in the delivery of the new curriculum and therefore created guidelines for assessment.

Characteristics of good assessment should include the following:

- (i) using a wide variety of assessment strategies and tools:
- (ii) aligning assessment strategies and tools with curriculum and instructional techniques;
- and
- (iii) ensuring fairness both in application and scoring. (NSDE, 2000, p.9)

The Nova Scotia Department of Education allocated time, money, and resources to developing new student materials as well as inservicing teachers on the use of these materials and alternate

teaching practices. In 2001, the Grade 12 mathematics curriculum, the last to be developed by the APEF, was implemented throughout Nova Scotia. Time was also spent addressing assessment. Compared to the other components of curriculum implementation, the time spent on assessment was disproportionately short. This was largely due to issues of funding (R. MacKinnon, personal interview, June 8, 2004).

As one measure of how well the new curriculum outcomes were being met, the NSDE implemented an external provincial exam in Grade 12 academic mathematics and Grade 12 advanced mathematics. All Grade 12 academic and advanced mathematics students are required to complete this common exam at the end of their course and it was valued as 30% of their final mark for that course. Intensive efforts have been made by the Testing and Evaluation Division of the Department of Education to insure that the exam was fair to both teachers and students throughout the province. Exam items are extensively field-tested and then reviewed by a committee of teachers. Prior to the first provincial exam, professional development sessions were conducted for all Grade 12 mathematics teachers throughout the province explaining how the exam was being created and providing numerous sample items. The NSDE conducted the first provincial external Grade 12 exams in January of 2004. The results of these exams at both levels were disappointing, particularly at the regular academic level. A provincial average of 54 percent was obtained in Advanced Math 12 and 41 percent in Academic Math 12 (NSDE, 2006).

The results from the external exam have triggered interest in the assessment practices used by Nova Scotia teachers. This study is concerned with identifying the assessment techniques that teachers use and the rationale for using such techniques. This study, however, is not concerned with examining assessment practices that lead to better student performance on the provincial external exam.

### *Overview of the Thesis*

Assessment is an integral component of the teaching/learning process. Assessment, both formal and informal, gives teachers insights into the level of student understanding so that ongoing instructional decisions can be made (NCTM, 2000, Swan 1993, Webb, 1992). In addition to this, assessment allows teachers to provide feedback to parents and student about the child's knowledge and understanding of mathematical concepts (NCTM, 2000, Swan 1993, Webb, 1992). Current mathematical pedagogy suggests that assessment practices should complement the instruction practices (NCTM, 1989, 2000). For example, if the classroom instruction supports discovery learning and problem solving, then the resulting assessment practices and items should include novel open-ended problems. These types of problems align with the daily teaching practices in this type of learning environment. In Nova Scotia, information regarding the relationship between teaching practices and assessment practices is limited.

This qualitative study is designed to examine the assessment practices used by four Grade 12 mathematics teachers in the province of Nova Scotia and gain insights into the factors that influenced the use of such practices. Therefore, four underlying questions directed this study:

- (1) What types of assessment practices have the teachers heard of?
- (2) What types of assessment practices are being used by these Grade 12 mathematics teachers, why are these practices being used, and what was the perceived effect of using such assessment techniques?
- (3) What types of assessment practices have these teachers heard of but chosen not to use? What is their rationale for not selecting these practices?
- (4) If the teachers have changed their assessment practices since the start of their teaching careers, how were such changes accomplished and what influenced such changes?

While addressing these questions, the following themes were also probed:

- (1) What are these teachers' conceptions of mathematics and have these conceptions changed over time and with experience?
- (2) Do the teaching practices of these teacher reflect the teaching practices endorsed by the Nova Scotia Department of Education?
- (3) Do the assessment practices of these teachers reflect the assessment practices endorsed by the Nova Scotia Department of Education?
- (4) What issues have influenced the implementation of the new Grade 12 curriculum either positively or negatively for each of the participants in the study?
- (5) What types of assessment practices are considered exemplary and by whom and in what context?

The teachers were identified by a former Mathematics Consultant for the province of Nova Scotia. He/she agreed to supply a list of potential candidates when the project was approved by the Ethics Committee. The consultant indicated that the following criteria was used in his/her selection process.

- (1) The recommended teachers are involved in ongoing professional development.
- (2) The recommended teachers are viewed as respected leaders among their peers.
- (3) The recommended teachers follow the prescribed curriculum.
- (4) The recommended teachers use teaching and assessment practices that align with the practices endorsed by the Department of Education.

The decision to use the former consultant in the selection process was based on two factors. The first factor dealt with the consultant's level of expertise. The consultant had spent the last ten years in curriculum development. During this time he/she had devoted a significant amount of his/her personal time to studying the NCTM's recommendations regarding assessment. The

former consultant is considered knowledgeable and a leader in many areas, including assessment. The second factor dealt with the consultant's familiarity with Grade 12 mathematics teachers in the province. Over the consultant's career, he/she had the opportunity to work with and observe this diverse group of professionals. This allowed him/her to identify teachers that adopted and embraced the new curriculum and the recommended assessment practices.

By using the teachers recommended by the former consultant, I obtained a list of teachers that engaged in diverse, and sometimes unique, assessment practices. This project was interested in telling their stories regarding assessment practices. My interest did not lie in contrasting their assessment practices nor generalizing that certain assessment practices should be shared by all teachers.

It is anticipated that teachers who read this thesis will be exposed to a variety of assessment techniques and rationales for selecting such techniques. This may allow the readers to critically analyze their own assessment practices, if they choose.

### *Conceptualizing Myself*

Many educational research reports leave pertinent information regarding the author out of the text. Such reports fail to acknowledge that the author's judgements, biases and evolving views influence the scope and direction of the inquiry. "The omission is not the result of forgetfulness, but rather reflects the assumption that to present data that will be convincing and deemed legitimate, attempts must be made to bracket out the subjective. The illusion created by this bracketing can be convincing." (Gitlin & Russell, 1994, p. 187) Identifying the author's location provides the reader of this thesis greater insight into the choice of the research topic, the method by which the data was collected, and how the data was interpreted.

Early in my career, my initiatives inside and outside the classroom were noticed by several individuals at the Department of Education. My enthusiasm, ability to solve unique problems using unconventional means, and progressive teaching practices had drawn attention. These individuals asked me to sit on a variety of committees and attend numerous workshops. Within a few years my involvement on curriculum teams and providing professional development throughout the Atlantic provinces grew exponentially. This eventually led to writing opportunities with a major Canadian publishing company, several teaching awards, and employment within the mathematics department at a local university. In terms of classroom experience, Grade 9 to 12 mathematics has been the primary focus for my twenty year career, specializing in advanced mathematics courses at the Grade 11 and 12 levels.

Although an advocate for the public school system over my career, personal disillusion in the system has been growing over the last year. There are several reasons for this. The first reason focuses on what I describe as a disconnect between the Department of Education and the front-line teachers that work with students every day. Policy decisions do not appear to always consider what is best in terms of students' educational needs. It also appears that teacher opinion is seldom or reluctantly factored into the decision-making process. Policies on semestering, homework, prerequisites for courses, mandatory high school credits, individualized program planning, and teaching loads appear to contradict fundamental practices of good teaching. It should be stressed that my dissatisfaction does not extend to the present or past mathematics consultants for the Department of Education. From my perspective, they have made every effort to improve mathematics education within the province.

The second reason for my disillusion focuses on issues of accountability. Accountability should rest on the shoulders of all parties in the educational process. This includes students, teachers, administrators, parents, school boards, Department of Education, and the Minister of Education.

Unfortunately, in many of our schools today, accountability appears only to focus on the teacher. Teachers no longer deliver only curriculum. They are motivators, councilors, parole officers, negotiators, and disciplinarians. They are expected to multi-task, delivering more than one program within the same period yet still meet the learning needs of all students.

The third and final reason for my disillusion is directly connected to my own child's experience in the public school system. My child has unique learning needs. For the last six years, my wife and myself have worked cooperatively with teachers, administrators, tutors, child psychologists, developmental pediatricians, and speech therapists in an attempt to address his learning needs. These endeavors over this period of time cost our family approximately thirty thousand dollars, and that figure continues to grow. Although all parties worked to serve our child's best interests, it ultimately became clear that the public school system didn't have the time, money, resources, or personnel to truly address his needs. In 2005, we enrolled our child in a private school specifically designed to address his learning style.

## CHAPTER 2

### Review of Related Literature

In the first two sections of this chapter, two themes are examined: teacher conceptions of mathematics and educational change. In the third and final section, assessment in the climate of mathematical reform will be examined. This will include examples of assessment techniques suggested by researchers, and elaborate on any benefits and drawbacks associated with these assessment techniques.

#### *Teacher Conceptions of Mathematics*

A teacher's conception of mathematics may be viewed as that teacher's philosophy of mathematics. It is derived from his or her conscious and subconscious beliefs, views, concepts, and preferences regarding mathematics (Thompson, 1992). Although teacher conceptions of mathematics vary greatly, Ernest found that they generally fall into three categories (Ernest as cited in Thompson, 1992).

- (1) In the first category, teachers perceive mathematics as dynamic; a continually expanding field of creativity, imagination and invention. Problem-solving is integral and students are required to understand patterns and use that understanding to create knowledge.
- (2) In the second category, teachers perceive mathematics as a static but unified body of knowledge bound together by meaning and logic. All the truths are known.
- (3) In the third category, teachers perceive mathematics as a collection of facts, skills and algorithms. Therefore to be strong mathematically means that one must use these facts, skills, and algorithms expediently and efficiently.

Of these three, the one that aligns with the Nova Scotia mathematics curriculum is the view that mathematics is dynamic and creative.

Teacher conceptions of mathematics can be deeply rooted in their own formal education (Ball as cited in Thompson, 1992, Cooney, Shealy & Arnold, 1998). Many teachers are products of very traditional practices and curriculums where instruction was designed to lead students through explicit and very systematic lessons that would ultimately lead to the mastery of content. For this reason many teachers tend to view mathematics as static and driven by logic, Ernest's second category, or as a collection of facts, skills and algorithms, Ernest's third category. Although these conceptions are not without merit, they fail to recognize the diversity of authentic mathematical problems. Authentic problems include novel, open-ended, and real world problems. When teachers subscribe to either of these conceptions of mathematics, the teachers and their students may encounter difficulties when attempting novel or unusual problems. With these types of problems, the over-reliance on practiced procedures is often not sufficient to complete the question (Cooney, 1994, Hatano as cited in Markovits & Sowder, 1994). These teachers and students lack the necessary conceptual knowledge required to address the problems because they have failed to explore the concepts and construct their own meaning and connections.

If long-held, deeply rooted traditional teacher beliefs of mathematics may effect instructional practices and if these beliefs are in conflict with the prescribed curriculum, how can these teacher beliefs be modified? One approach is to use resources that may force teachers to reexamine or challenge their own beliefs. These resources should be inundated with novel problem-solving situations that cause confusion, doubt and controversy (AECT, 2000, Cooney, Shealy & Arnold, 1998, Thompson, 1992). New resources alone however, will not suffice. For example in one study, Simon and Tzur (1999) observed a teacher giving her students an open-ended task yet wanted the students to respond in one particular manner. In addition to this, the teacher failed to initiate discussion or attempt to ascertain the level of student understanding. The resource (i.e.

the open-ended task) alone did not affect change in her teaching practices or her conception of mathematics. Support in the form of ongoing long term professional development must also be provided for teachers if such a paradigm shift is to occur (Philipp, Flores & Sowder, 1994, Simon & Tzur, 1999).

If teacher conceptions of mathematics are to change, new and innovative resources should be accompanied by professional support that encourages teachers to reexamine their beliefs. For example, in one study, thirty student teachers were interviewed regarding their conceptions of mathematics prior to and after receiving a mathematics methods courses that promoted problem solving and the use of open-ended problems. For these student teachers, “mathematics had shifted from being a subject conceived around mathematical themes or types of questions to becoming something more oriented to activities for children.” (Brown et al, 1999, p. 31) These teachers now advocated investigative learning and valued the interconnectiveness of concepts. These teachers no longer advocated teaching by transmission where teacher comments were generally addressed the correctness of the individual student work.

Having teachers reflect upon the diversity in their classroom may encourage change in their teaching practices and ultimately their conceptions of mathematics. In one study, researchers observed that teachers who were reflective practitioners were more likely to move away from the traditional model for mathematics teaching and embrace reform approaches (Philipp, Flores & Sowder, 1994). These teachers were concerned with the wide range of student abilities in their classes and were pleased to use multiple-entry problems that allowed all students to be challenged without feeling frustrated. Although this study was concerned with diversity in terms of ability, teachers may wish to consider diversity associated with student interests, learning styles and skills.

Research has shown that a teacher's knowledge and awareness of conceptual interconnections in mathematics is influenced by the continuing long term commitment to math-specific professional development (Brown et al, 1999, Eisenburg as cited in Fennema & Franke, 1992, Wittman as cited in Cooney, 1994). Teachers, who are prepared to explore the dynamic nature of mathematics, will develop new insights and learn to celebrate alternate and sometimes nonstandard approaches to problems. This, in turn, influences their knowledge of the discipline of mathematics. Teacher knowledge is not influenced by the number of mathematics courses taken at the post-secondary level.

The strategies previously mentioned all require teachers to reexamine their beliefs. The strategies, however, do not always guarantee that teacher conceptions of mathematics will necessarily change to dynamic and creative form. Some teachers will adopt the new teaching practices but not accept the more progressive and dynamic view of mathematics. They merely accept the practices in favor of seeking agreement and harmony (Cooney, Shealy & Arnold, 1998). Other researchers agree with this finding (Brown as cited in Thompson, 1992, Simon & Tzur, 1999). They state that there is no consistent relationship between a teacher's professed beliefs and the instructional practices they select. Another situation can arise when attempting to change teacher conceptions of mathematics. Some teachers will filter the information and materials provided to them, selecting only those pieces of evidence that support their own interpretation of mathematics and mathematics teaching (Cooney, Shealy & Arnold, 1998).

Teacher conceptions of mathematics not only effect how and what a student learns but it may also effect the instructional practices and materials a teacher wishes to use (Cooney, 1994, Kuhs & Ball as cited in Thompson, 1992). Teachers who subscribe to a dynamic and creative conception of mathematics tend to endorse the discovery approach to the teaching of mathematics. Using this approach, teachers are facilitators of learning and students are actively

involved in exploring mathematics and formulating ideas (Thompson, 1992). Teachers who subscribe to a static yet logic-driven conception of mathematics endorse approaches that “emphasizes student understanding of the logical relations among various mathematical ideas and concepts and logic underlying mathematical procedures.” (Thompson, 1992, p. 136) Teachers who perceive mathematics as a collection of facts, skills and algorithms, tend to teach with a focus on content with emphasis on performance. This necessitates a great deal of repetition and very few true problem-solving situations (Thompson, 1992).

### *Educational Change*

The introduction of the reformed mathematics curriculum designed by the Nova Scotia Department of Education, requires teachers to change more than just the classroom resource. Teachers should reflect on their conceptions of mathematics and their teaching practices and assessment practices. If change is required, several factors might impede such change.

- (1) Teacher opposition can occur if the innovations appear to conflict with the values and beliefs held by the teacher or teachers (Ellsworth, 2000). Such opposition can relate directly to teacher conceptions of mathematics, a matter previously discussed in this paper. In terms of the adopting curriculum reform, some teachers believe that the new approach might be confusing students with too many unusual and novel tasks such that the student can't recognize and understand the underlying concepts (Dufour-Janvier, Bednarz & Belanger as cited in Noble et al, 2001). These teachers may believe in the dynamic and creative conception of mathematics however, they are not prepared to adopt some practices that they believe do not serve the needs and abilities of their students.

- (2) Some teachers feel that the system as a whole is incapable of such change (Ellsworth, 2000). They perceive that the system lacks the resources, expertise, leadership and/or resolve to follow through with the innovations and therefore the teacher is unwilling to initiate or fully implement the prescribed change.
- (3) Teachers who do not feel capable of change will not attempt change (Goodman & Dean, 1982). They feel that they lack the experience or knowledge so they fail to adopt the new approach.
- (4) Teachers who do not perceive awards, implicit or explicit, for adopting new practices, are unlikely to participate (Goodman & Dean, 1982). If they do not believe that their efforts will be recognized or appreciated by all parties, including other teachers, they will not adopt the innovation. If they do not believe that student performance will improve, they resist change.
- (5) Some teachers and/or administrators perceive innovation as a means of eroding their status in the classroom or school. As a result of this, they will resist change, and in some cases disrupt or distort the change process (Ellsworth, 2000).
- (6) Two groups, students and parents/guardians, are often underestimated in terms of their influence on change initiatives (Fullan & Stiegelbauer as cited in Clarke, 1994, Peressini, 1997). New approaches are often viewed negatively by these groups especially when they deviate from the “drill and practice” methods that they perceive as mathematics.

(7) Teachers and parents/guardians are apprehensive to adopt changes if there is a perception that the research community has voiced concerns or identified inequities regarding the proposed changes. For example, there are some unresolved issues regarding the reformed mathematics curriculum and its impact on low SES (socioeconomic status) students. Although Lubienski (2000) recognizes that reform mathematics curriculum can be beneficial to both low SES and high SES students, the effects with each group are not proportional. The low SES students improve in their conceptual understanding of mathematics but not to the same degree as high SES students. As a result the gap between low SES and high SES students widen with the implementation of reform mathematics curriculum. These types of unresolved issues can cause confusion among teachers and parents/guardians and may result in opposition to change.

If these are the factors that may impede change, what can be done to address these concerns and to promote long-term and widespread change? Based on the research, five strategies can be employed to accomplish such change.

- (1) A clear vision of the proposed change must be conveyed to the teachers (Clarke, 1994, Goodman & Dean, 1994) and a clear statement of commitment must be provided by the people in leadership roles (Ellsworth, 2000, Goodman & Dean, 1994).
- (2) Change is a gradual process that requires patience on the part of the individuals recommending the change. Sometimes the language that one uses to describe change fails to recognize how change occurs in small increments. Often the words, success and failure are used when discussing change. These words, however, are

problematic. Instead, descriptors, which reflect the degree or level of change that has occurred, should be used (Goodman & Dean, 1982). These descriptors describe the frequency and evolution of behavior as the individuals gradually adopt change. Secada and Byrd (1993) state that schools are likely to initially pursue different avenues of mathematics reform and address different issues at different rates even though they are attempting to adopt the same philosophy, teaching practices and assessment techniques. Clarke (1994) agrees with this, stating that such change is gradual.

- (3) Research recommends that all parties that will be affected by the change (students, parents/guardians, administrators, councilors,... ) should be informed prior to implementation so that they can understand the rationale for such change and be provided the opportunity to ask questions. In terms of eliciting parental support Peressini (1997) offers several suggestions designed to open communication so that parents/guardians can understand the rationale for the curriculum changes. She recommends the use of parent mathematics night where parent watch students working on mathematics problems and in some cases participating in the actual lesson. She also recommends the use of a “parent switch” day where parents/guardians take the place of their child and actively participate in the mathematics classes. Newsletters can also be used to keep parents/guardians informed of the proposed changes. Peressini observed that most of these suggestions are quite successful with parents/guardians of children in elementary grades however, they were far less effective with parents/guardians of children in high school.
- (4) If one wishes to be proactive and minimize resistance, it is recommended that time and attention must be given to address the concerns raised by all stakeholders (Clarke,

1994, AECT, 2000). To overcome obstacles to change, resistance must be confronted directly and be viewed as feedback that assists in the planning of further intervention (Zaltman & Duncan as cited in AECT, 2000).

- (5) Extensive professional development is critical if change is going to occur (Clarke, 1994, Ellsworth, 2000, Lappan et al as cited in Cooney, 1994). However, it should be stressed that this means sustained professional development over at least a two year period while providing both intellectual and emotional support. New information acquired in single and isolated workshops did not have the same impact on classroom practices as sustained and coordinated professional development (Lappan et al as cited in Cooney, 1994).

When limited to isolated one day workshops, professional development opportunities can fall short of their intended goals. Cooney (1994) cautions that some professional development concentrates on expanding teacher knowledge but fails to address how such knowledge can impact daily practices. Teachers need to know why such changes are being endorsed but also how such changes can be incorporated into their classroom practices. The knowledge can be obtained in single isolated workshops however, with long term professional development teachers can see how such knowledge can impact their daily teaching practices.

Professional development must be integrated into the teacher's classroom role. A portion of professional development time should be allotted so that teachers can share with colleagues and reflect upon practices that were considered successful and/or exemplary (Clark, 1994). Several benefits can occur with these types of exchanges.

- Teachers walk away with knowledge obtained from their peers.

- Teacher gain a sense of ownership as they and their peers have contributed to the process of change.
- Teachers can reflect upon their own practices (Clarke, 1994) and identify the obstacles they may encounter. They can then attempt to develop strategies for dealing with such obstacles whether they be at an individual, school, or board level (Cooney, 1994, Clarke, 1994).
- Teachers are more likely to initiate change if they believe that other teachers perceive the benefits of such change and that other teachers have adopted the change (Goodman & Dean, 1982)
- Teachers have the opportunity to network and create support groups to deal with the emotional and intellectual problems associated with change. Too often teachers work in isolation and such exchanges do not occur. In one study of high school teachers, researchers discovered that 46% of teachers spent one hour or less with colleagues discussing matters of curriculum and/or instruction (Moles as cited in Clarke, 1994).

(6) External exams or testing are considered powerful tools in influencing change.

Although one might argue that teachers ultimately teach for the test, the tests do influence both what material is taught and how that material is taught (MacIntosh, 1994, Romberg, Zarinnia & Williams as cited in Lesh & Lamon, 1992). Research (Hawker & Ollerton, 1999, McNeil as cited in Schorr, Firestone & Monfils, 2003, Newsome & Thompson, 2002, Swan, 1993) argues that such external exams do not result in the desired changes. Swan (1993) contends that such exams tend to “place a premium on the fluent performance of technical routines in stereotyped contexts” (Swan, 1993, p. 39) and therefore do not support the notion that mathematics is dynamic and creative; an important aspect of curriculum reform. Others caution that

by using external exams, the exams dictate the curriculum rather than the curriculum dictating the exam (Hawker & Ollerton, 1999).

One researcher stated that external exams also produce negative effects such as “pushing children out of school to undermining challenging teaching and learning.” (McNeil as cited in Schorr, Firestone & Monfils, 2003, p. 376). Other researchers argue that more time should be spent trying to improve classroom assessment, rather than assessment on external exams (Senk & Beckmann, 1997). They state that the adoption of the reformed curriculum and reformed assessment techniques will occur by concentrating on teacher professional development rather than by concentrating on external exams.

One group of researchers (Snyder, Bolin, & Zumwalt as cited in Clarke, 1994) cautioned about some teacher’s tendency to adapt, rather than adopt, new approaches. They stated that this might occur when professional development is initiated in a manner that reduces the scale of the project and/or the gradient of the actual change proposed. True change is often difficult and painful, so reducing this to bring it back to the teachers’ “comfort zone” can ultimately be a disservice to the new approaches, the teacher, and their students.

### *Assessment*

In order to more clearly understand the topic under investigation, a working definition of assessment is required. For this research, the purpose of assessment is to determine what a student or groups of students know about mathematics and how they think about mathematics (Buschman, 2001, Lee, 2001, Lesh & Lamon, 1992, NCTM, 1989, Webb, 1993). This information is used by teachers to make ongoing instructional decisions and to provide feedback about the child’s knowledge and understanding of mathematical concepts to the parents/guardians and student (NCTM, 2000, Swan, 1993, Webb, 1992). For school boards and

government agencies, assessment is used to judge the effectiveness of programs (NCTM, 1989, Webb 1992).

Assessment is sometimes confused with evaluation. Evaluation is the assigned value or grade one gives to the results from assessment (Lesh & Lamon, 1992, Webb, 1992). Many teachers confuse the terms assessment and evaluation. When asked about their assessment practices, they mistakenly refer to the marks students have earned on tests, quizzes or other graded assignments (Senk & Beckmann, 1997).

Prior to the curriculum reform proposed by the NCTM, the vision of assessment was narrow (Morgan, 2000). This vision was built on two underlying assumptions. First, students possess knowledge skills and understanding that are discoverable and measurable. Second, the purpose of assessment is to discover and measure the student's knowledge, understanding, and skills. These assumptions are rooted in the positivist tradition where one believes that there is an underlying truth to be examined and discovered. Based on these assumptions, assessment was designed to discover that truth by eliminating bias. This interpretation resulted in assessment practices that largely tested skills, facts, and procedures. Open-ended and problem-solving questions were not endorsed. The reason given is that this requires the teacher to interpret student information, resulting in potential bias (Morgan, 2000). The influence of this view of assessment is still affecting the assessment practices of teachers today. Many teachers today are still assessing skills and facts, instead of trying to interpret the level of student understanding (Webb, 1992).

With the introduction of curriculum reform proposed by the NCTM, a broader view of assessment emerged. The following criteria can be used to define this new vision of assessment.

- (1) Assessment, and its results should be viewed as a means to achieve educational goals, rather than merely providing a measure (Clarke, 1997, NCTM, 1989, 2000).
  
- (2) Assessment is continuous and dynamic (NCTM, 1989, 2000, Webb, 1993).  
Assessment is “a process of observation, conjecture, and constant reformulation of judgements about student understanding” (NCTM, 1989, p. 203) where teachers try to understand the meanings students assign to mathematical ideas (Webb, 1993). It is no longer viewed as an isolated event that occurs at the end of an educational experience.
  
- (3) Assessment should include a variety of assessment techniques, both formal and informal (Lesh & Lamon, 1993, Marlow, 2000, NCTM, 1989, 2000, Swan, 1993, Van Den Heuvel-Panhuizen & Becker, 2003, Webb, 1992). Over-reliance on formal assessment that often relies on students to complete “paper-and-pencil” tasks in an allotted time can be problematic. The teacher can be left with an incomplete or distorted view of what the child truly understands. It can also frustrate students and lower their self-esteem which may manifest as math anxiety (NCTM, 1989).  
Multiple strategies and/or multiple solutions are not best studied using formal assessment. Informal assessment techniques assist in giving teachers a clearer picture of the level of student understanding. These allow students to use their thinking abilities, apply their knowledge, and show their individual capabilities (Morgan & Watson, 2003, NCTM, 1989, 2000, Van Den Heuvel-Panhuizen & Becker, 2003, Webb, 1992).
  
- (4) Assessment can guide teachers as they make instructional decisions. (Buschman, 2001, Lee, 2001, NCTM, 1989, 2000, Schorr at al, 2003, Swan, 1993, Webb, 1992).

This is referred to as formative assessment and it allows teachers to identify student achievements, errors and difficulties so that this information can be used to design appropriate follow-up activities.

- (5) Assessment can be used to judge students' abilities to meet the outcomes of a prescribed curriculum. (NCTM, 2000, Swan, 1993, Webb, 1992). This is referred to as summative assessment and it allows teacher to rank student performance in terms external criteria.
- (6) Assessment should celebrate student achievements, provide continuous feedback, and help the child move forward to meet their next goal (Clarke & Atkinson as cited in Morgan, 2000) while fostering self-esteem and self-confidence (Morgan, 2000).
- (7) Assessment should include authentic assessment tasks. If these tasks are authentic, they should incorporate more reasoning, multi-step problem-solving, a variety of possible strategies, and the use of technology (De Lange, 1993, Shannon & Zawojewski, 1995, Senk & Beckmann, 1997, Van Den Heuvel-Panhuizen & Becker, 2003). These tasks should "invite students to display their mathematical understanding through constructed rather than remembered responses." (Clarke, 1997, p. iii) These tasks should also align with the reforms proposed by the NCTM (Lesh & Lamon, 1992).
- (8) A wide range of assessment techniques should be employed. By doing this, the teacher is recognizing the diversity among his/her students and attempting to incorporate assessment practices that are fair and acknowledge such diversity. These techniques might include projects, presentations, discussions, interviews, portfolios,

and observations (Lesh & Lamon, 1992). The issue of fairness also effects the choice of contexts for a given assessment task. Some research raises concerns that some minority groups can be exposed to further inequity if the assessment uses unfamiliar cultural contexts (Baker & O'Neil as cited in Morgan & Watson, 2002, CRAME, 1993). For the assessment to be fair, students should know the criteria by which their response is going to be judged. This may mean that the students are supplied with the rubric so that they can understand which responses will be considered exemplary opposed to those that are considered mediocre (NCTM, 2000).

In terms of assessment, the Nova Scotia Department of Education requires that three fundamental principles are followed (NSDE, 2000). The first principle is that a wide variety of assessment strategies and tools are employed on an on-going basis. This means that teachers must go beyond using just tests and assignments to assess student understanding. Assessment should be occurring on a daily basis and may include presentations, discussions, projects, and journals. The second principle is that the assessment strategies and tools must align with the curriculum and instructional techniques endorsed by the Department. Since the curriculum celebrates diversity in terms of the solution strategies employed and, in some cases, the solutions obtained, then the assessment must celebrate that same diversity. If the curriculum stresses conceptual understanding, then the same should be true for the assessment. The third principle is that the assessment is fair as defined in the Principles for Fair Student Assessment Practices for Education in Canada. This document states that the directions regarding assessment, provided to the students, "should be clear, complete, and appropriate for the ability, age, and grade level of the student" and that the "content and language that would generally be viewed as sensitive, sexist or offensive should be avoided." (CRAME, 1993, p.2)

With this broader definition of assessment outlined, one researcher (Webb, 1993) went on to state that any form of assessment, formal or informal, has five common features. These features are stated below.

- (1) The first feature is comprised of the question or task that is presented to the student. Some tasks should be challenging and complex and require the student to work at his/her maximum level of ability (NCTM, 1989).
- (2) The second feature is the student response to that question or task. The particular form of the response is dictated by nature of the question, the purpose of the assessment, and the amount of allotted time. The allotted time refers to both the time the student is given to complete the task and the time the teacher needs to assess the response (Webb, 1992). It should be noted that there is always a possibility that the responses will vary greatly and that some students may interpret the task and/or respond to the task in a form that the designer of the task had not expected (Noble et al., 2001). Teachers should be prepared to celebrate different levels of sophistication when dealing with student responses (NCTM, 1989).
- (3) The third feature is the teacher's interpretation of the student response, which requires that the teacher make inferences about the student's understanding and knowledge of mathematics. This can be problematic because teachers may choose to focus on criteria that they value in the domain hence there can be a level of bias (Morgan & Watson, 2002, Pollard as cited in Litherland, 1997). Other research demonstrates that the same teacher can interpret similar response differently depending on the impressions a teacher may have formed regarding an individual student (Rapaille as cited in Morgan & Watson, 2002).

- (4) The fourth feature is judging the student's response with respect to a range of all possible student responses. For example, the sophistication of a particular student solution is often judged in relation to the sophistication of solutions supplied by his/her peers.
  
- (5) The fifth feature involves the reporting and recording the findings from the assessment. This may take the form of a mark, an anecdotal comment, or verbal feedback.

Most teachers are comfortable with traditional assessment techniques such as tests, quizzes and assignments. In this section, some alternate forms of assessment are examined. These include the five minute wrap-up questions, teacher-student interviews, open-ended projects, self-assessment, peer-assessment and portfolio learning.

Lee (2001) proposes the use of an informal type of assessment that could best be described as the five minute wrap-up questions. She proposes that in the last five minutes of class, a student can be asked to explain what he/she has learned during the class. Classmates would listen, determine if any pertinent information was left out, and ask the student questions. This informs the teacher of any student concerns or misconceptions. It also allows students to reflect upon and obtain a better understanding of the concepts covered in that class.

Interviews are a method of informal assessment recommended by Buschman (2001). Individual teacher-student interviews allow the teacher to quickly identify the level of student understanding and determine if any additional support is required. They also allow teachers to examine other aspects of student performance such as patience, perseverance, and positive

outlook, which can not be recognized with some other forms of assessment. Interviews provide valuable insights regarding student understanding so that the teacher can develop better problems which can focus on misconceptions held by students. From a student's perspective, interviews provide students with immediate and useable feedback for improving future performance. Students also appreciate the more comfortable problem-solving environment of interviews because their responses are not scrutinized by their peers. (Buschman, 2001)

Swan (1993) suggests that extended, more open-ended tasks that may take three to fifteen hours to complete should be given to students. Although he recognizes that short and well-defined assessment tasks are useful, he states that these short tasks provide a limited view of student understanding. For this reason, he advocates the use of more lengthy problems but stresses that students should have a clear understanding of teacher expectations for such problems. One approach is to supply the students with the rubrics for the various components of the problem. This allows the students to recognize when they have met a specific expectation. He also recommends that the students should be prepared to justify why they have met that expectation. By requiring student justification, the teacher conveys the message that the process is under scrutiny, not just the final answer.

Self-assessment and peer assessment has a positive effect on student learning (Lee, 2001, Stallings & Tascione, 1996, Swan, 1993, Wilson & Kenny as cited in NCTM, 2000). Students who are engaged in self-assessment are likely to reflect upon the strategies they used or were about to employ (Kenny & Silver, 1993). Students feel satisfied and empowered with self assessment especially when the teacher and student had come to a clear understanding of what criteria had to be met to satisfy the teacher expectations for the task (Petit & Zawojewski, 1997). Stalling and Tascione (1996) proposed a novel form of self-assessment, which was quite effective. After a student completed a test, it was marked and then returned to the student. The

student was then required to submit a written assessment of their test performance where they described the errors they make distinguishing between conceptual errors and procedural errors, and also provide corrected solutions to problems. This form of assessment forced student to reflect upon the paths they had chosen on the test and address any misconceptions. It should be noted that some students did struggle with self-assessment because they tended to weigh effort heavily regardless of the quality of the product however, clear and simple assessment criteria can alleviate some of these problems.

Portfolios can be used as a form of assessment. There are some distinct advantages and disadvantages to this form of assessment (Marlow, 2000).

#### Advantages

- (1) The material within portfolios represents evidence of ongoing mathematical learning.
- (2) The material represents what the student has actually done in class.
- (3) The materials relate directly to the outcomes in the prescribed curriculum.
- (4) Students take ownership of the portfolio since they had a strong influence in determining the content of the portfolio.
- (5) If teachers review portfolios on a regular basis, the feedback to the students and parents/guardians is immediate.

The two major disadvantages are that assessing portfolios is both difficult and extremely time consuming. Unless rubrics are used and clearly stated to students, then it can be difficult to compare and recognize the merits of each portfolio. However, the time required to read portfolios is the largest concern. It can, in some cases, cut into valuable preparation time (Marlow 2000). Yet research indicates that for portfolio learning to be effective, teachers should methodically go through the student responses and provide constructive feedback; a very time consuming process (Lesh and Lamon, 1992).

If alternate forms of assessment are advocated by researchers, why are these new forms seldom used by teachers? Research has identified several reasons for this discrepancy.

- (1) In some cases, teacher conceptions of mathematics do not align with the reformed mathematics curriculum as outline in the NCTM Standards document and hence the conceptions do not align with the reforms in assessment (Morgan, 2000, Morgan and Watson, 2002).
- (2) Teachers can lack the confidence or knowledge to employ alternate forms of assessment or to find appropriate assessment tasks (Morgan & Watson, 2002, Senk & Beckmann, 1997, Webb, 1992).
- (3) Teachers are not exposed to exemplary teachers who use a variety of assessment techniques. They need these role models who can offer support and direction when requested (Herrington, Herrington & Glazer, 2002).
- (4) Time is a contributing factor. It takes more time to develop, administer and interpret alternate assessment techniques (Senk & Beckmann, 1997).
- (5) Although teachers are informed about what constitutes good assessment, little professional development time is allocated to showing teachers how to balance new forms of assessment with older more traditional forms. They are uncertain as how these individuals forms of assessment should be weighed. In addition to this, teachers who do use alternate forms of assessment disagree as to which of these forms is the most useful assessment tool (Senk & Beckmann, 1997).

- (6) Change is a gradual and demanding process and the same is true regarding assessment reform (Webb, 1992). One should anticipate that change typically only occurs in increments of about 10% each year (Leinwand as cited in Senk & Beckmann, 1997).
- (8) Teachers fail to adopt reformed assessment practices if they perceive that such changes do not align with expectations of external groups or authorities such as parents/guardians, school boards, post-secondary institutions, employers, and/or politicians (Morgan, 2000).
- (9) Teachers perceive that students do not value some reform assessment practices because they fail to provide consistent or sustained effort when completing such tasks. Wilson (1994) proposes that many alternate forms of assessment are not graded. High school students are typically quite savvy about budgeting their time and energy therefore if their activity is not graded, then it is not valued by the students and the benefits of such forms of assessment are not recognized by the students.

Morgan and Watson (2002) raise concerns regarding the equity of some informal assessment. They are concerned that there are several factors that inevitably and unavoidably influence informal assessment and that these factors have little to do with mathematical ability. Informal assessment can be influenced by

- the teacher's initial impression of student's mathematical ability prior to being given the assigned task.,
- the student's social skills,
- time constraints, which do not allow the teacher to fully explore the level of student understanding,

- the teacher's inability to see or use all the details occurring in a classroom, and
- what the teacher perceives as appropriate approaches and behavior for handling such a task.

Morgan and Watson (2002) raise similar concerns regarding the teacher assessment of written mathematics. In some cases, the match or mismatch of the students writing to the form of mathematical writing desired by the teacher strongly influenced the results regardless of the mathematical content. In another case in the same study, the same text received rankings from B to E on a scale from A to G by different teachers. Clausen-May (2001) raises another concern regarding written mathematics. She states that with more open-ended written mathematics, it is very difficult to create a rubric in advance that can account for the diversity of possible responses and therefore inconsistency will occur during the assessment process.

The types of assessment and the value given to different assessment tasks conveys to students what information the teacher feels is important. This influences the student and how they should explore and study the material (Clausen-May, 2000, Litherland, 1997, NCTM, 2000, Webb, 1992). This too can be problematic. If the teachers focuses on the procedural aspects or symbolic manipulation of a given task at the expense of the conceptual understanding, then the students will interpret this and might adopt practices that impede conceptual understanding (Litherland, 1997).

## CHAPTER 3

### Method and Methodology

This thesis is offered, in an interpretivist approach and in the postmodernist tradition, as a means of giving voice to Grade 12 teachers who are attempting to use a variety of assessment practices in their classrooms as advocated by the Department of Education.

#### *Method*

“Method refers to techniques for gathering empirical evidence; methodology is the theory of knowledge and the interpretive framework that guides a particular research project” (Harding as cited in MacLeod, 2002 ,p.34). As a postmodernist researcher, I favor a method and methodology that gives voice to the marginalized, considers the context in which the data is collected and interpreted, examines the complexity of a given situation, and recognizes that this complexity is everchanging. I am not bounded by the ideology that there is one knowable truth that can only be obtained through rigorous scientific method. For these reasons and reasons of manageability, I chose to conduct a qualitative research study comprised of four participants.

Defining qualitative research is far more difficult than identifying it. (Boeree, 1998, Bogdan & Biklen, 1998, Schram, 2003, Shank, 1995) Six distinct features of qualitative research can be identified, where some of these features are present in varying degrees or not present at all, depending upon the qualitative study one examines.

#### (1) Natualistic

The qualitative researcher enters the particular setting to collect the data. The interaction with relevant individuals is long-term, in-depth, and context is examined (Bogdan & Biklen, 1998, Glesne & Corinne, 1999, Stainback & Stainback, 1988).

This particular study would not be considered naturalistic. Although the interviews were in-depth and the context was considered, they were not conducted in a classroom setting where one could examine the participants using their assessment techniques.

## (2) Descriptive Data

The data is collected in the form of words or pictures, relying on written notes, tape recordings, video recording and/or still pictures. The data is not reduced to numerical symbols but rather examined with all of its richness still intact with the intent of identifying themes. The resulting qualitative reports often contain quotations that describe a particular situation or view in a specific context (Boeree, 1998, Bogdan & Biklen, 1998, Glesne & Corinne, 1999, Shank, 1995). "Taking something out of context is to distort it (or) to change its meaning." (Patton as cited in Schram, 2003)

This particular study used descriptive data. During the interview process, tape recording were made and notes were taken. These were later transcribed and common themes amongst the participant's stories were identified.

## (3) Inductive Reasoning

Qualitative researchers tend to rely on inductive reasoning where one moves from specific observations to broader generalizations and theories. They do not attempt to collect data in a form that allows them to prove or disprove a specific hypothesis (Bogdan & Biklen, 1998, Glesne & Corinne, 1999, Shank, 1995, Stainback & Stainback, 1988).

This research project was not implemented in an attempt to prove or disprove a particular hypothesis, but rather, it was designed to be flexible, open-ended , and driven by the participants' stories.

#### (4) Value Bound

In quantitative studies, methodological procedures are employed in an attempt to make the study value free. By contrast, in qualitative studies, one recognizes that the researcher's values shade and guide the research topic, questions, interpretation, and theories. As the researcher attempts to construct a reality to the inquiry, she/he constantly making their own value judgements (Stainback & Stainback, 1988, Lincoln and Guba as cited in Shank, 1995).

I recognize that my voice, experience concerns and bias do influence the interpretation of the data. My study does not attempt to hide behind the illusion of objectivity, rather the study clearly identifies such issues to the reader so they can understand how my own values have influenced the interpretation.

#### (5) Concern with the Process

For qualitative researchers, the focus is on the process rather than the outcome. Since the object of their research is to examine an issue in all its complexity, qualitative researchers are continually reflecting on techniques that expose this complexity (Bogdan & Biklen, 1998, Schram, 2003). "You will undertake inquiry not so much to achieve closure in the form of definite answers to a problem but rather to generate questions that raise critical awareness and understanding of problems. Your distinctive contribution will lie in raising questions about ideas otherwise taken for granted or left unasked." (Barone as cited in Schram, 2003, p. 6) Bogdan and Biklen

(1998) take this further when they state, "How do people negotiate meaning? How do certain labels come to be applied? How do certain notions come to be taken as part of what we know as common sense? What is the natural history of the activity or events under study?" (p.6).

This study did not attempt to bring closure to the issue of assessment practices in Grade 12 mathematics. It was designed to show the complexity of this situation and how the issues regarding assessment change from teacher to teacher, school to school, and year to year. Although attempts would be made to identify common themes, ultimately the study would unearth new questions that would likely require further research.

#### (6) Participant Perspectives

The qualitative researcher believes that reality is socially constructed so she/he is continually examining how participants make sense of their lives. What is the reality that these participants perceive? What have they taken for granted? Do they perceive that change can take place? What assumptions have they made? (Bogdan & Biklen, 1998, Stainback & Stainback, 1988).

In this study, participants would not only be asked about assessment practices that they used or were aware of, but also asked numerous questions that attempt to understand how they perceived themselves and mathematics in their particular setting. They would be asked about the school in which they teach, their education backgrounds, their conceptions of mathematics, and teaching practices.

## *Research Design*

### *Participant selection.*

A list of potential participants was supplied by a former provincial mathematics consultant in November 2005. The list included the mailing addresses and personal phone numbers of each of the teachers. The former consultant stated that these individuals were identified based on their on-going professional development, leadership in mathematics, and implementation of teaching practices, assessment practices, and the curriculum endorsed by the Nova Scotia Department of Education. It should be stated that the teachers were not selected based on their students' performance on the provincial external exam. This study is not concerned with examining assessment practices that lead to better student performance on the provincial external exam. Rather, it is concerned with identifying the assessment techniques that these four teachers use and the rationale for using such techniques.

The potential participants were organized on a new list based on their proximity to the researcher; those living closest to the researcher were at the top of the list. All contact with these potential participants, and later with the four selected participants in the study, occurred at their homes or on the campus of Mount Saint Vincent University. The selection was limited to four for reasons of manageability however, it was anticipated that four participants would still offer a diversity of assessment practices. All mailings and phone calls were made to their primary residence. E-mails were not made to accounts that were run by the Department of Education. By eliminating any contact with or potential involvement of the school or school board, ethical approval from the individual school boards was not required.

An Information Letter to Potential Participants (Appendix A) was sent to their homes. The letter outlined the purpose of the study and indicated the nature of the questions that would be asked during the individual interviews. The specific questions however were not provided at

this time. The potential participants were informed that questions would concentrate in four specific areas:

- (1) the teacher's conceptions of mathematics,
- (2) the assessment practices used by these teachers,
- (3) the rationale for using such assessment practices, and
- (4) the perceived effects of using such practices.

The letter also stated that their participation was strictly voluntary and if they choose to participate, they were insured confidentiality and anonymity.

Approximately one week after the mailing of the information letter, phone contact was made by the researcher to determine which individuals wished to participate in the study. If the teacher required clarification regarding the study or a component of the study, it was provided at that time.

Participation in this research project was voluntary, and required informed consent. The first four teachers who expressed interest in participating in the study were sent a Consent to Participate form (Appendix B). "Informed consent means the knowing consent of individuals to participate as an exercise of choice, free from any element of fraud, deceit, duress, or similar unfair inducement or manipulation." (Berg, 2004, p.64). The consent forms were signed and returned prior to the interview and these forms were kept locked in my office drawer and shredded upon the completion of the study.

#### *The interview process.*

When the consent form was returned to the researcher, phone or e-mail contact was made with the participant to arrange the interview schedule. The participants decided whether the interview

took place at their home or at the Seaton Academic Centre on the Mount Saint Vincent University campus. The participants also selected a time that was convenient for them.

Each teacher participated in a one to one in depth, open-ended interview with myself. It was explained to each teacher that her/his identity would remain anonymous. The interviews were audiotaped using two machines so that if a problem arose with one machine, the other would serve as a backup. The interviews were between 1 to 1.5 hours in length. For two of the interviews, telephone conversations took place several weeks after the interviews when clarification or elaboration was required to a participant's response. Most of these clarifications focused on the educational background of the participant.

The interview questions were classified in three categories; general questions regarding the teacher, questions regarding the school in which they teach, and specific questions regarding assessment and related assessment issues.

#### General Question Regarding the Teacher

- (1) How many years have you been teaching mathematics?
- (2) Have you taught at the same school for your entire career?
- (3) Do you teach Academic Mathematics 12, Advanced Mathematics 12 or both? How many sections of these courses have you taught and over how many years?
- (4) Professional development comes in many forms. Describe your professional development over your mathematics teaching career?

#### Questions Regarding the School

- (1) What type of community does your school serve?
- (2) Approximately how many students are enrolled in your school?

- (3) In the typical year, how many days are lost due to school cancellations?
- (4) Is your school semestered or nonsemestered?
- (5) What is the average class size of your mathematics 12 classes?
- (6) Describe the scheduling of classes.

#### Specific Questions Regarding Assessment and Related Assessment Issues

- (1) Describe your personal view of the discipline of mathematics.
- (2) Does your personal view of mathematics influence what you teach and how you teach it? Why or why not?
- (3) Have your teaching practices changed over your career? If so, in what ways have they changed and what factors were instrumental in driving this change?
- (4) What does assessment in mathematics mean to you?
- (5) What types of assessment practices have you heard of?
- (6) Have your assessment practices changed over your career? If so, in what ways have they changed and what factors were instrumental in driving this change?
- (7) What types of assessment techniques or tasks do you use and why have you chosen these forms of assessment?
- (8) What did you learn from using these forms of assessment and would you consider them time well spent by you and your students?
- (9) Are there forms of assessment in math that you do not use? If so, what are these and why don't you use them?
- (10) If you were required to use some of these other forms of assessment, what supports from your school, your school board and the Department of Education would be necessary?

(11) Do you believe that your assessment practices, teaching practices and conceptions of mathematics align and compliment each other? Explain. How does this fit with the curriculum prescribed by the Department of Education?

Although the interviews were open-ended, a structured interview guide was used to insure that all pertinent items were addressed and that each participant was asked similar questions. Participants were also encouraged to discuss related issues that they felt were important. In circumstances where participants had difficulties answering particular questions, time was provided such that they could reflect upon the question and their response. If this was not sufficient, then elaborations to the questions were provided. Following the interview, if the participant had any thoughts concerning their responses to the questions, they were encouraged to contact myself by phone or e-mail.

Additionally, participants were provided with the opportunity to offer feedback concerning her/his depiction in the final paper. A first draft of her/his "story" was sent via email so that they could review it. They were encouraged to read the draft and recommend changes. This was done to insure that participants were comfortable with their participation in this research. In addition, I did not want the participants to feel that they had been misrepresented or that the information betrayed their anonymity.

#### *Data collection.*

Although the questions were constructed prior to the interview, participants were encouraged to discuss other matters that they felt were pertinent to their stories. Ultimately the interviews were conversational yet semi-structured in nature. I was not an observer, but rather an active and interested participant in the discussion. Seidman (1991) states, "The most important personal characteristic interviewers must have is a genuine interest in other people. They must be deeply

aware that other people's stories are of worth in and of themselves and because they offer something to the interviewer's experience." (p.71) "The research relationship is a partnership. It is not a series of detached observations about subjects by intentionally uninvolved researchers. Instead, subjective qualitative researchers consciously avoid such barriers between themselves and their subject." (Toma as cited in MacLeod, 2002, p.37)

### *Data analysis.*

Following the interviews, I transcribed the data, and began to analyze it. Initially one set of data was examined at a time. During the interview process, participants would often return to past questions or address future questions. For these reasons, it took several weeks to organize the information from one transcription such that one could obtain a clearer understanding of the participant's "story." Once this was completed, the stories and transcriptions were analyzed collectively, looking for common themes among these experienced teachers as they attempted to address a variety of assessment issues in Grade 12 mathematics. It should be noted no quantitative or statistical conclusions should be drawn from these interviews. A sample size of four restricts the generalizations of findings from the study to all Grade 12 mathematics teachers throughout the province of Nova Scotia. My research, like other forms of qualitative research " is meant to be transformative; we do not merely analyze or study an object to gain greater understanding, but instead struggle to investigate how individuals and groups might be better able to change situations. (Tierney, 1994, p. 99)".

### *Ethical Considerations*

#### *Informed consent.*

Potential participants were supplied with an information letter (Appendix A) that briefly described the purpose of the research project and the nature of the questions that would be asked

during the interview process. The four individuals who agreed to participate in the study were sent a Consent to Participate form (Appendix B). These two documents indicated that the interviews would be audiotaped, the participant would be able to view and edit the transcription of her/his interview, that participation was strictly voluntarily, and that they were permitted to terminate their participation in the study at any time.

#### *Avoidance of harm.*

Assessment practices are not merely governed by the individual teacher. The Nova Scotia Department of Education and school boards also set policies that directly and indirectly affect assessment practices. Issues of power can affect the voices of teachers.

At times, silence can be more a lack of acceptable voice, not an absence of voice.

Teachers do discuss educational issues, but these issues tend to be skewed towards classroom concerns. Teachers' tendency to focus on these sorts of issues has much to do with the expectation that no one of importance will listen or consider their views. They have grown to anticipate the continuance of school structures and mandates, instigated without input and often in the face of their objections. (Gitlin & Russell, 1994, p.200)

Teachers who participated in this study had the opportunity to express their views, yet may have felt vulnerable by doing so. With this in mind, I proceeded with care and sensitivity, and practiced discretion when undertaking this study.

#### *Confidentiality.*

Pseudonyms were used throughout the research study for each teacher and care was taken to insure that descriptions of particular location or individual characteristics about the individual did not make it possible to discover the individual's identity. No person other than myself had access to the interview tapes or the transcription of those tapes. Participants were able to access the tapes and transcripts of their own interviews. The tapes and transcriptions were kept in a

locked filing cabinet in my office at my home. Any work completed on the computer was inaccessible to anyone other than myself. One year after the completion of the thesis, the tapes will be destroyed, transcriptions will be shredded, and related computer files will be deleted.

### *Methodology*

The thesis was approached from an interpretivist and postmodernist perspective.

Qualitative methods are generally supported by the interpretivist (also referred to as constructivist) paradigm, which portrays a world in which reality is socially constructed, complex and everchanging. . . .The researchers seek out the variety of perspectives; they do not try to reduce the multiple interpretations to a norm. (Glesne & Corinne, 1999, p.5)

The interpretivist recognizes that their personal phenomenological orientation will affect the interpretation of the data, yet she/he will endeavour to examine the complex and interwoven variables in an attempt to find patterns (Berg, 2004, Glesne & Corinne, 1999, Schram, 2003).

The researcher tries to understand the reality from the perspective of the person who lives it and in doing so takes on a more personal involvement and continually refining your interpretations. (Glesne & Corinne, 1999, Schram, 2003). "One role of researchers is to paint portraits of possibility." (Tierney, 1994, p.112) The interpretivist approach does not infer that the researcher must take on a change-oriented posture, however, it is difficult for any qualitative researcher to claim that their study isn't designed to encourage reform (Schram, 2003).

By stark contrast to the interpretivist approach, the positivist tradition professes that scientific method should be employed to insure that the research is "value free" and discovers the "knowable truth." The assumption is that the reality is fixed, measurable and can be replicated if the researcher carefully designs the questions and technical procedures that mask the "intractable uncertainties and unstable ambiguities" of life and language. (Dennett, 1998, Glesne & Corinne, 1999, Morgan, 2000, Schram 2003, Scheurich, 1997). Objectivity is a priority to the researcher.

Their role is to observe, measure, and use systematic rigor to eliminate those uncertainties and ambiguities associated with lived experiences. The research becomes a "rhetorical reduction of complexity to simplicity, of differential relations to firm identities." (Ryan as cited in Scheurich, 1997, p.63)

Is it possible to take complex human interaction and communication in different contexts, and eliminate or reduce the uncertainties such that purely scientific techniques can be employed to discover the "truth?" Boeree (1998) states that such positivist traditions in research can leave one with a very incomplete story.

While reducing everything to numbers may be justified in the physical science, doing the same to human experience seems to dismiss the other non-quantitative dimensions of the experience. How do you quantify meaning, for example to love, or anger, or confusion? You can describe the Grand Canyon using only number -- but somehow that wouldn't capture the essence of it. (p.2)

However positivist would argue that the practices of interpretivist researchers, like those of other qualitative researchers, fail to address the issue of objectivity and validity. In terms of objectivity, qualitative researchers recognize and struggle with the notion that their prior knowledge, experience, and bias can affect the interpretation of the data. Therefore qualitative research does not have the same goals as those proposed by positivists. "(Educational) research cannot be accepted as truth but rather as a focus for discussion and comparison to the practical concerns of teachers." (Gitlin & Russell, 1994, p.200) In terms of validity, if the qualitative researcher can not produce a complete story that is somehow true, predictable, and can be replicated, is the research valid? This debate continues. Lather (1994) addresses this fixation with validity best when he states, " Validity is a limit question of research, one that repeatedly

resurfaces, one that can neither be avoided or resolved, a fertile obsession given its intractability." (p.37)

As previously mentioned, this thesis was also written in the postmodern tradition. Postmodernism was largely a reaction to the assumed certainties of science to explain reality. Postmodernists are highly skeptical of results that profess to be representative of all groups, cultures and races. When results of this nature are released, postmodernists are concerned that groups within our society are marginalized. They are interested in giving voice to these individuals and thus empowering them. I felt that my role as a researcher was to give serve as a conduit such that the stories of these four classroom teachers could be told. Too often the words of our 'front-line' teachers are ignored in favour of research articles from varied contexts or reports from government sponsored agencies removed from the rigor of daily classroom life.

The fact that classroom teachers are overworked and minimally supported by salary, materials, or support staff appropriate to the value of their work and years of practice blurred by the expertise postures of corporate- or government-supported "outside consultant" model." (Leck, 1994, p.79)

The postmodern approach also appeals to my own sense of validity. Will my results be valid? If one considers my location when I designed the questions, when I conducted the interview, and when I interpreted the results, and then factors in the location of the participant at that place and time, the answer is "yes." Do I believe that another researcher would reach the same conclusions, asking the same questions to the same participants at different times and possibly locations? I don't believe so.

(The) postmodernist perspective suggests that the researcher has multiple intentions and desires, some of which are consciously known and some of which are not. The same is true of the interviewee. The language out of which the questions are constructed is not bound or stable; it is persistently slippery, unstable, and ambiguous from person to person, from situation to situation, from time to time. (Scheurich, 1997, p.62)

My research was designed to examine the complex issues associated with assessment in mathematics at the Grade 12 level, give voice to four teachers, and provoke further discussion in this area which have largely been ignored in our province.

## CHAPTER 4

### The Participants' Stories

#### *The Research Participants and the Schools in which They Teach*

Each of the participants has at least 18 years of classroom experience and would be considered a leader in mathematics within their school. They are all white, middleclass, married and have at least one child.

#### *Andrea.*

Andrea was contacted in December of 2004 and agreed to participate in the study despite the fact that she had recently taken on a new position, which was extremely time-consuming. We met to conduct the interview one evening in a classroom on the campus of Mount Saint Vincent University. The interview took about one hour and thirty minutes to complete. I have had the privilege of working with Andrea on several committees over the last ten years, and I have always viewed her as a leader in mathematics within this province. Her patience, extensive mathematical knowledge and constructive comments were always valued in these settings.

Andrea has been teaching mathematics for over 20 years. For her first years, she taught in another province and she later moved to Nova Scotia where she initially taught in a rural school board. Following this, she transferred to the Halifax School Board, where she taught in several junior and senior high schools.

In terms of education, Andrea has a Bachelor of Science in mathematics with honours, a Bachelor of Education, a Master of Education, and partially completed the course requirements for a second masters degree. In terms of professional development, Andrea has repeatedly taken on leadership roles within different mathematics organizations and educational firms.

Andrea's experience teaching the new Grade 12 mathematics curriculum is limited to teaching two sections of the Grade 12 advanced course in 2003. However, she has taught most of the new secondary mathematics courses which all advocate the use of discovery learning. This experience was acquired while working in a high school within the Halifax Regional Municipality (H.R.M.). The student population at her school is between 1000 and 1300, and the school is considered multicultural. Class sizes are typically in the low 30's for academic courses and in the high 30's for advanced courses. For the Grade 10 and foundation mathematics courses, the school attempts to keep the numbers between twenty and thirty. The school timetable works on a five day cycle where each day has five 60 minute periods. That means that one course each day is scheduled in for two periods; the first and last. Teaching in the H.R.M. results in very few official cancellations for inclement weather however, busses are generally cancelled 3 to 5 times a year during the winter months. Since her school has several busloads of students travelling in each day, the withdrawal of bussing services does affect the school. The bussed students are obviously unable to attend, and many of the students who walk take it upon themselves not to attend. With this significant reduction in the student population on these days, the school day is ruined and little new work gets done. Little class time is lost at Andrea's school for assemblies or for other events where a large group of students would be present.

*Craig.*

Craig was the second participant to take part in the study. We met to conduct the interview one evening in a classroom on the campus of Mount Saint Vincent University. The interview took about one hour and thirty minutes to complete. Although I had spoken to Craig at several inservices and felt that his comments were intelligent and thought provoking, I did not have any opportunities to work closely with Craig and therefore was not familiar with his accomplishments in mathematics education.

Craig has been teaching mathematics for over 20 years. His first few years were in a private school, where he taught math, chemistry, and physics. He was later hired by the Halifax Board, where he taught at both the junior high and senior high levels. Craig worked in administrative roles at two of the high schools, however, it is not a position that he wishes to pursue further. Returning to the classroom full-time was his wish. Since Craig has worked in several different schools and has always been eager to teach a variety of courses, he has the unique experience of teaching most of the high school mathematics courses in both the past and present curriculum.

In terms of education, Craig has a Bachelor of Science, a Bachelor of Education, and a Master of Education. In terms of professional development, Craig has taken on leadership roles examining student learning styles, and curriculum development in mathematics and science. One of his last major contributions occurred when he was a participant on his Board's Student Assessment and Evaluation Policy Committee. For reasons that will be discussed later, this committee ultimately left Craig with many concerns regarding the direction of formal assessment within his Board. Craig has also completed over fifteen different presentations for a variety of mathematics organizations over his career.

When it comes to teaching the new Grade 12 mathematics curriculum, Craig has the most experience of the four participants in this study. He has taught at least two sections of advanced math 12 each year and he recently taught three sections of academic math 12. The class size in both the academic and advanced math 12 classes are typically 32. The student population at Craig's school is between 700 and 1000, and the school serves a very diverse social economic community. Students ranged from low social economic status (SES) to very high SES. In this semestered school, the timetable works on a four day cycle where each day has four 80 minute periods. Grade 10 students take a full load, taking eight courses over the year. Grade 11

students take seven courses while most Grade 12 students are only enrolled in six courses. If Grade 11 or 12 students wish to increase their load, they can only do so as long as an opening is available however, additional sections will not be created to accommodate these individuals wishing to pursue further studies. Teaching in the H.R.M. results in very few cancellations for inclement weather and Craig feels that on average only four days per school year are lost.

*Ryan.*

Ryan was contacted in December of 2004 and agreed to participate in the study even though he had several prior commitments to his school and family. The interview was conducted at his home, the most convenient location for Ryan. The interview took a little more than one hour. Although I had not worked directly with Ryan on any committees or projects, I had talked extensively with him during professional development sessions. It was clear during these discussions that Ryan was very passionate about teaching mathematics. He was always eager to discuss innovations and initiatives he and his school were incorporating in their teaching and assessment practices.

Ryan has been teaching for over 20 years. His first two positions were at rural high schools where he taught in several subject areas including mathematics. It was not until he transferred to his present school that he concentrated solely on the discipline of mathematics.

In terms of education, Ryan completed a Bachelor of Science Degree. Upon completion, he entered Nova Scotia Teachers College where he received an Associate License in Education. From the beginning of his teaching career, Ryan attended as many professional development opportunities as possible, and later he was consistently asked to provide workshops for both the Mathematics Teachers Association and for his school board. In the early 1990's, he completed a

Masters of Education. Three of the courses were pure math courses while the remaining two courses concentrated on teaching methods for mathematics. During this time, he conducted several workshops at the university he was attending. Ryan has also served on two provincial implementation teams.

Ryan's experience teaching the new Grade 12 mathematics curriculum is limited to the Grade 12 advanced course, however, he has taught this program for several years, usually having four sections of the course each year. Ryan has also taught the new Grade 10 curriculum in prior years. Under the old curriculum, he has taught Grade 10 General Math, Grade 10 Academic Math, Grade 11 General Math, Grade 11 Academic Math, PreCalculus 12, and Grade 12 General Math.

The student population at his school is between 1200 and 1700, and the school serves a large town and surrounding communities predominately comprised of "white collar working families." Students', as well as parents', perceptions of mathematics vary from those "who see no need of math to those who realize that it has a function." Ryan's school is nonsemestered and the timetable works on a seven day cycle where teachers see each class five times during the cycle. Four of the five periods each day are 55 minutes in length while the one remaining period is 70 minutes. Ryan estimates that the typical class size is "30 plus or minus 2" students. The number of days lost due to inclement weather, inservices, and parent teacher conferences is between 12 and 18 school days.

*Denise.*

Denise was contacted in December of 2004 and agreed to participate in the study despite the fact that she was teaching eight classes this year, leaving her with no preparation time in either

semester. Several months later we met to conduct the interview. This took place at her home and was approximately one hour in length. Although I've never had the privilege of working with Denise on committees, I knew that she had served in several leadership roles within her own school board. On the few occasions that I had spoken to her, I found her enthusiastic, professional, and receptive to new ideas.

Denise has been teaching mathematics for over 15 years. Her first year was at a small rural high school and the remaining years have been at her current high school. She is a full time classroom teacher. In terms of education, Denise received her teaching diploma from Nova Scotia Teachers College and promptly took five full credits during her first year of teaching. These credits were primarily methods courses, and they allowed her to obtain a license increase. A few years later, she took five additional credits in a variety of disciplines, and this allowed her to obtain her Bachelor of Education. In the last few years, Denise completed a Masters of Education. In terms of professional development, Denise has volunteered and worked on the School Improvement Committee and the Board's Grade 10 Implementation Team. She has also conducted numerous workshops on behalf of her board and the Mathematics Teachers Association.

Denise has the unique experience of teaching both Mathematics 12 Academic and Mathematics 12 Advanced in a nonsemestered system, a partially semestered system, and semestered system. Her school has tried several scheduling options in an attempt to find a system that best serves the students and teachers, yet allows the school to offer all necessary credits in a timely fashion. They were ultimately forced by the Department of Education to adopt the semestering model, a model that according to Denise, doesn't serve the needs of many students. Denise's school is comprised of approximately 850 students from grades seven to twelve. It serves several rural communities that are predominately white and of a lower to middle social economic status.

Class sizes in Math 12 Academic are typically twenty-five and the Math 12 Advanced are generally about twenty students. These reasonable numbers are a stark contrast to those for Math 10 where class sizes often start out at thirty-five.

The school timetable works on an eight day cycle where each day is comprised of five one hour classes. This means that for each course, there are two double periods in the eight day cycle, however, one double is the first and second periods in the morning, and the other is the first and last periods in the day. Denise prefers this over the traditional four day cycle where the student has two concurrent periods of math once every four days.

Her school typically loses about five to six days a year for school cancellations but Denise is further troubled by the number of days that are lost by individual students near the end of the year. Students often miss whole days for track and field, softball, fashion shows, and other sanctioned events. She finds this frustrating as this time is critical to many of these students as they will be writing the Provincial Math Exam.

### *Andrea's Story*

#### *Andrea's conceptions of mathematics.*

When asked about her concepts of mathematics, Andrea stated that mathematics was analogous to sports. Most individuals are not gifted in a particular sport however, with time and practice, most can become quite competent in that activity.

There's a really nice analogy to sports, . . . if you really like a sport, you're going to work at it, you're going to perfect your skills, you're going to do drills so that your body learns the motions it has to go through to be successful. You don't assume that by watching

somebody do something, that you will know how to do it, you just know that. Math is not a spectator's sport. It's something you have to work at, and there's dignity in that work, you know, it's, you make a mistake, you find out what your mistake is, you clean it up, and you go at it again, and in working through the math, you're making decisions all the time, okay. At every step you're asking yourself what do I do next, what do I know? It's very complex.

With continued questioning, Andrea said that the "mental gymnastics" associated with mathematics drew her to this discipline. The expectation that one had to exercise their mind to complete a question or series of questions always appealed to her. She acknowledged that this interest was probably fostered by her father, who encouraged puzzles and problem solving. Although Andrea is confident in her problem-solving abilities, she doesn't feel the same level of confidence when it comes to creating her own problem solving questions, despite her continued involvement with a variety of writing committees. She states, "I didn't think I could create problems, and that's still not a strength."

Much later in the interview this topic regarding her conceptions of mathematics surfaced again. Andrea enjoys mathematics because she perceives it as a series of interconnected topics that are bound by understanding rather than by the memorization of facts or rote procedures.

You didn't have to remember a thousand different things. Maybe that answers the question too, why I went into math. I don't have a memory. So in math, you don't have to remember stuff, you know, you remembered the bare minimum, and then fit it together in a new way, and you're there.

Andrea's conceptions of mathematics can be summarized by the following. Mathematics is a series of interconnected topics bounded by understanding and fostered by problem solving and perseverance.

*Andrea's teaching practices.*

Andrea's conceptions of mathematics have influenced what material she has taught and how that material has been taught however, she has not altered or ignored curriculum because of her conceptions. For example, problem solving has been an integral part of Andrea's conception of mathematics and was a significant component of her teaching practices particularly in the first twenty years of her career. Prior to the introduction of semesters, she regularly scheduled classes where students worked in groups on a variety of problem solving activities.

When I taught junior high, would have been a long time ago and we weren't semestered, and in the city we had Grade 10 enriched classes, well, we had fun. I could find wonderful problems to get my kids going on, contest problems or whatever. That was great.

With the introduction of semesters and an outcome-laden curriculum, Andrea now finds little time to spend on problem solving with any of the mathematics courses at the secondary level. She finds this disappointing, She believes, however, that if she had the opportunity to teach the Math 10 Plus program or their school-based Math 10 enriched program, she could again incorporate problem solving activities.

Andrea believes that mathematics is built on understanding and illustrates the interconnectiveness of topics within this discipline and with other disciplines. With the

introduction of the Math 431 and Math 441 programs in the early 1980's, Andrea had the opportunity to teach a program which illustrated how various mathematical concepts flowed and complimented each other. She embraced these programs as they supported her belief in how mathematics should be taught. Andrea's reaction to the current mathematics curriculum is mixed. Although her conceptions of mathematics support the investigative approach and working from the concrete to the abstract in context, she feels that the new programs do not fulfil all necessary requirements. She believes that many of the investigations and the contexts in which they are presented, are forced. Based on this, she feels that some teachers have now become disillusioned with the investigative approach.

The new curriculum kind of fits into that, because that tries to start from the concrete, although I think that a lot of times, for me at least, the context can get in the way, because it's not a context I think is as good a fit as it might be and in terms of practice, like the investigative approach, I think we needed a lot more support with how to make that work. Because I think even people who started out positive about that, have done an about face, and are back to less investigation.

Andrea stated that interconnectiveness of mathematics with other disciplines was integral. While working as a consultant for an education firm, Andrea was able to put this into practice. In this setting, she had the opportunity to work with consultants from other disciplines and develop materials that connected mathematics with other subjects. Unfortunately Andrea doesn't believe that this belief ultimately changed her teaching practices.

I learned a lot about technology, because I was left very much on my own to figure things out. Learned a lot about the mathematics in other disciplines; biology, chemistry, and you know, coming up with ways of building on something that was happening, maybe

that somebody was writing in geography, and trying to dig out the mathematics of it, and make it fit the curriculum. Now how much of that I took back to my classroom, I can't, I'm – the pressures of curriculum in a regular classroom just destroyed my chances on, or maybe destroyed my initiative, whatever, but I can't claim I did a lot of it.

Later in our conversation, she does acknowledge that she likes the Grade 11 and 12 programs. Her criticism is more directed towards the Grade 10 program.

Probably the one I think is the least finished, is Grade 10... It's not connected, lots of disjoint stuff, and in some cases, there's not enough substance. For example, the section on data management, just doesn't have enough meat to get it to where it has to be to set the stage for Grade 11.

Andrea previously stated that mathematics is "not a spectator's sport" and requires perseverance however, she acknowledges that this has caused her problems. She wants her students to focus on the details supplied in questions, recognizing what must be found, determine the pertinent information that is supplied, deciding upon and implementing a strategy or strategies. This can be a very time consuming process.

...there's not a lot of time to do that in the classroom, and students are not all in the same place, so I find it really challenging to figure out what it is that I need to spend time on in the classroom without boring some, and overtaxing others.

Although Andrea attempts to have her conceptions of mathematics influence her teaching practices, she is mindful of the curriculum and how that curriculum is to be delivered. If time is

of the essence or if her idea is not aligned with a curriculum outcome, she will not allow it to influence her teaching practices.

Andrea's teaching practices have changed over her career, most strongly influenced by the work of two individuals; a professor at the University of Toronto and a department head at one of her early postings. There was a professor from the University of Toronto that Andrea believed modelled exceptional teaching practices. This professor would start by assessing what his students knew and worked from there. His lessons typically involved using concrete examples. He had the ability to make the most abstract concepts understandable and much of that was intrinsically tied to his line of questioning that forced student to reflect on the concepts be presented. "He gave it meaning." Andrea has tried to model her own teaching practices based on what she observed from this individual.

When she started her career Andrea was teaching Grade 13 calculus in Ontario, her expectations for her students were very high. Andrea explained her self-described rigid expectations as "I show, and you do, and you do well." Admittedly she stated that this philosophy may be fine for a high level university preparatory course but was probably not well suited for most secondary mathematics courses. This became apparent to Andrea when she moved to Nova Scotia and started teaching at East Pictou. There she met her new department head, another individual who was instrumental in changing Andrea's teaching practices. From Andrea's perspective, he was the first teacher who emphasized the concept, opposed to the skill. When teaching a new topic, he would start off slowly using as many concrete materials and/or props to give students a sound understanding of the underlying concept. Only when this foundation was established, would he increase the pace. Not only did he show Andrea how concepts should be taught but he also demonstrated how the pace of delivery was critical.

The introduction of the Math 431 and 441 programs, coupled with a few inservices from the Department of Education, reaffirmed what Andrea had believed about mathematics; it should be interconnective. She liked the approach advocated in this curriculum and incorporated it into her teaching practices.

*Andrea's views on assessment.*

When asked what assessment meant to her, Andrea responded, "Getting a read on where the students are." At this point in the interview she was referring to the feedback the teacher receives regarding individual students. Several minutes later Andrea stated that assessment should provide feedback to the student "to help them know what they had to do next to improve." Andrea implied that assessment should be fair when she stated she didn't want to create assessment items that penalized "students who were slower at picking it (the concepts) up." She wanted to create a non-threatening environment where students could demonstrate what they knew. That was the reason why she had implemented group quizzes and later in our conversation she indicated that it was her motivation for using frequent and varied assessment techniques. Andrea also said "way too often, as I see it now, I think it (assessment) meant assigning a mark." Until recently, she had felt compelled to assign a mark, opposed to giving some other form of feedback. In her recent position, Andrea has had the opportunity to examine research that suggests that marks are not a means to motivate students. For this reason, she is now questioning the practicality of assigning a mark to every item a student passes in. Andrea raised another important point at this stage in the questioning. She was concerned that a significant amount of time had been spent developing and inservicing teachers on the delivery of the new secondary mathematics curriculum however, very little direction had been provided from the Department of Education on how student performance should be assessed. She felt this was a glaring omission.

When Andrea was asked about the types of assessment practices she had heard of, she provided an extensive list and informed me that she had attempted to use all of this, some of which she later abandoned. She provided the following examples of assessment techniques in this particular order.

(1) Quizzes

Andrea indicated that she has used traditional quizzes, pair quizzes, group quizzes, homework quizzes and open-book quizzes.

(2) Tests and Exams

(3) Assignments

These include individual assignments as well as group assignments.

(4) Portfolios

From Andrea's perspective, portfolios could be described as mathematical scrapbooks where students had the freedom to add what they felt was important. This might include a piece of work, a writing response, an activity the student struggled with, or any other material that would demonstrate growth.

(5) Journals

From Andrea's perspective, journals were not as open-ended as portfolios. Students should be given a question or two as a homework assignment and be asked to produce a written response to the question or questions. Andrea did state that portfolios and journals were similar in that they were reflective in nature.

(6) Independent Study Project/Chapter Projects

(7) Presentations

These vary from lengthy presentations derived from a research project to brief presentations where students explain the solution to a homework or assignment question.

(8) Observational Checklists

In this case, the teacher walks around the classroom observing students as they work on a group activity or assignment. The teacher uses a rubric to record whether the students are remaining on task, using the appropriate mathematical language, deciding on a strategy, implementing that strategy, and then checking the work they have completed.

(9) Homework Checks

With homework checks, the teacher monitors whether the homework is completed, records this information, and later assigns a mark at the end of the semester.

*Assessment practices that Andrea has used.*

From the nine different assessment practices that Andrea had heard of and used, there are three she is presently not using: portfolios, observational checklists, and homework checks. Andrea felt that she had very little success with portfolios. They were time-consuming for the students to complete and very time consuming for the teacher to assess and she saw only minimal gains for all involved. In a semestered system where time is at a premium, Andrea believes that

portfolios were not a good use of time. In terms of observational checklists, Andrea had attempted to use them a few years ago when she was teaching the Math 10 Plus course. She had doubts, however, regarding her ability to monitor and record what was taking place. Although she had created a rubric for this form of assessment, she wasn't confident that her anecdotal comments could later be used to assign a mark. She stated that this was an area she "would probably look to improve." The last assessment practice that Andrea is no longer using is homework checks. In the past, she would check homework in the following manner.

When I walked around to check homework, if the student had the homework done, they got a dot. If the student didn't have the homework done, they got a slash. If they came and showed me the homework a day or two later, a second slash was added in the opposite direction. So as far as I'm concerned, that homework's done, no penalty. Regardless of the reason, or whatever happened last night, don't tell me about it, I don't have time to listen, sorry, come and talk to me later, but get it done. It must be done.

Andrea was very pleased with her system because it clearly defined her expectations and motivated the students to complete the work. She was very disappointed when the Department of Education mandated that no marks were to be assigned for the completion of homework. The Department's reasoning was that all forms of assessment should be outcome-based. When Andrea returns to the classroom she is planning to replace homework checks with homework probes. With the probes, students will be asked to complete and submit a question or two from a previous night's homework. These responses will be marked and returned.

In terms of assessment practices that Andrea is still using, she started by mentioning quizzes, and tests that comprise 30% of the final mark. Andrea believes that quizzes should be brief and distinctly different from the more lengthy tests. Although she acknowledges that she still does

individual quizzes, she has been doing more pairs quizzes recently. The choice of pairs is sometimes done by the students, and at other times it is done by a random pick. What Andrea finds is that in these pairs quizzes, students are forced to communicate mathematically and explain and defend their line of reasoning.

The idea was they could learn from each other, they would have to use the language, they would have to formulate questions... even if they're simple questions, like how did you get that? So there was the whole communication thing.

To insure that students did communicate, Andrea always informed her students that she would only be marking one of the two submitted quizzes from each group.

I'd pull them both in, but I'd only mark one, and the idea would be you two had better agree on what you want on those papers, because you don't know which one I'm going to take in, and you're both going to live with that mark. So fight it out, do whatever you have to, but be sure that you're comfortable with what each of you has written, check it over.

Andrea discovered that there were three other benefits to using pair quizzes other than increasing communication and reasoning skills. Andrea realized that she had increased the number of quizzes she would typically give in a semester. Since Andrea was only marking half the number of papers, she felt she had more time to create and mark other quizzes. Another benefit was concerned with the types of questions she could ask on the pairs quiz. She felt that she could ask at least one question which was more challenging, requiring the students to consider a wider range of strategies and consider the interconnectiveness of topics. The third benefit, and it was previous mentioned, was the issue of fairness. Andrea believed that the pair quiz was less

threatening as it did not penalize students who were slower at picking up concepts. By working with a partner, even the slower student had an opportunity to contribute and to learn.

Andrea's assignments, which are typically worth ten percent of the final mark, are comprised of questions similar to those assigned as homework questions. She finds them useful when attempting to understand the level of student understanding regarding concepts covered over the previous week or week and a half. The assignments also provide a nice overview of topics for students as they prepare for an upcoming test. For these reasons, Andrea continues to use and finds assignments a beneficial component of her assessment practices.

Andrea stated that journals had become a major and worthwhile component of her new assessment practices. It was a means to get students to write about mathematics, forcing them to use the appropriate language, and conveying their level of understanding for particular concepts. Since the journals were more structured than portfolios, addressing one specific question at a time, she felt that the journals could be used effectively to determine if individual students were meeting the required outcomes.

Andrea and her colleagues at her high school have spent the last few years developing independent study units for the Grade 12 mathematics course and for other secondary mathematics courses. Some of her colleagues initially proposed that the independent study unit in Grade 12 should be on probability. Upon further deliberation this was not accepted as most believed that the probability unit required the greatest teacher supervision and assistance. The teachers eventually decided upon the coordinate geometry unit. The students were supplied with a series of sheets that had space to complete assigned questions from the textbook and a few additional questions created by the teachers. The students were also provided with a list of websites that could be accessed for explanations. When it was appropriate, some class time

could be provided to discuss difficulties students were encountering. Typically four weeks were given to complete the assignment. The independent study unit is worth a total of ten percent of the final mark - five for the test and five for the work handed in. Students write the test on the day the completed project questions are handed in. Both components are marked. However, if the student receives a mark of 75% or better on the test, then the student is rewarded five out of five for the project component.

This type of independent study project is also part of the Grade 11 mathematics curriculum and at Andrea's school, it has been included in the PreCalculus Program. In PreCalculus, the unit on complex numbers is handled using this type of assessment practice. Andrea mentioned that her school was attempting to incorporate such a project with their mathematics 10 classes but it was still in the development stages.

Andrea acknowledges that the decision to use independent study projects was initially motivated by concerns that teachers, including herself, would not be able to complete the mandated curriculum. Although these projects have assisted in alleviating some of the time concerns, there have been other benefits. Students appeared to be successful at working and learning independent of the teacher. Many students worked cooperatively to overcome obstacles and they appeared to be motivated to complete the assigned work. Andrea felt that some of that motivation may have been a result of the marking scheme. In the end, Andrea and her colleagues were pleased with the results, hence independent study units are an integral component of assessment practices at her school.

The prescribed student resources for all of the secondary mathematics courses in Nova Scotia typically include one chapter project for each chapter in the book. Andrea has used these projects in the past however, when she feels that time is running out to complete the assigned

curriculum, she acknowledges that the chapter projects are the first items to be omitted. The outcomes can all be addressed without doing these chapter projects.

When discussing presentations, Andrea focussed on presentations where students demonstrate their understanding of a homework or test questions, rather than presentations concerned with an assigned project. In Andrea's class, students are required to complete and explain solutions to homework or test problems to the class. She tries to make the process as comfortable as possible for all students by having students volunteer for the question they wish to present. For students who are a little shy or lack confidence, she makes arrangements for those individuals so that they can complete the required presentations.

What it is, is an opportunity for a student to get up to the front of the room, and explain something. It could be a question from homework, it could be a test question that students had difficulty with, instead of teacher taking it up, a student takes it up... In a couple of cases, students were really uncomfortable with that, so it was a matter finding a problem, and presenting it in front of a few friends at lunchtime in the classroom.

Each child is expected to present at least twice during a semester and each presentation is marked based on a five point rubic. The categories within this rubic include whether the student's solution was correct, was their explanation well thought out, did they show some level of enthusiasm, and did they use the appropriate mathematical language. These presentation points will eventually account for five percent of their final mark. Andrea finds presentation beneficial to all concerned. It gives her further insight into the level of student understanding and allows students to view student modelled solutions, opposed to teacher modelled solutions. As a result, students tend to observe different strategies and understand different lines of reasoning when classmates present, in some cases, alternate approaches to the same question. For this reason

Andrea will often get more than one student to present for one particular problem. The questioning that takes place between students and the presenter also encourages the use of mathematical language.

Andrea has attempted to employ a variety of assessment techniques, ultimately staying with those that produced the desired results without infringing too greatly on the precious class time. The more traditional assessment practices she uses are quizzes, tests, exams, and assignments. In the case of quizzes she has included pair quizzes to encourage communication and in some cases to increase the level of the types of questions she can ask. Other assessment practices, which she is still using, are journals, independent study projects, and presentations. All three of these practices allow the students to gain greater independence of the teacher, foster communication skills, and encourage further mathematical reasoning. Andrea states that she is always willing to consider alternate assessment practices in an attempt to create greater consistency between their teaching practices and her assessment practices. She does feel that there is adequate alignment between her conceptions of mathematics, teaching practices, and assessment practices, but is always striving for improvement.

#### *Changes in Andrea's assessment practices.*

When Andrea started teaching in the H.R.M. at the secondary level she, like most other teachers, was using a limited number of assessment techniques, and the use of these and their percentage values was very much at her discretion.

You might have one or two tests, a couple of quizzes, homework checks, and you had a mark, okay, at the end of the term, you also had an exam to throw in, a few more tests, and so on, but it was all very much individual practice.

Today, her assessment practices have changed considerably. Andrea has introduced a variety of new assessment techniques (journals, pair quizzes, presentations, independent study projects) that she considers meaningful in her given setting.

Some of those changes have been mandated, and it's not a bad thing that they were mandated... A lot more assessment, never a week goes by that you haven't got one or two assessment items of some kind coming in, and the exam's only worth 30 percent, tests and quizzes together another 30 percent, so 40 percent of the year's work needs to be meaningful, and not just fluff, but at the same time, give students other opportunities to show what they know.

Andrea stated that these changes were gradual and incremental, taking several years to reach their present position. What factors influenced Andrea's change in assessment practices?

Andrea cited several reasons.

#### (1) Mandated Changes

In an attempt to insure that assessment was fair, the Department of Education stated that final exams were not to exceed 30% of the final mark. The Halifax Regional School Board had similar concerns in regards to assessment practices. In an attempt to insure that assessment was ongoing and relied on a variety of assessment techniques, the H.R.S.B. stated that tests and quizzes were to only account for 30% of the final mark. This left 40% to be covered by alternate assessment techniques. Andrea states that these changes were needed and these mandates were a major factor in driving change in her assessment practices.

#### (2) Dialogue with Other Teachers

Andrea has been fortunate to work in settings that are collegial in which teachers from all levels are willing to exchange ideas and materials. This was first discussed when she talked about the collaboration required to develop the independent study units at her school. These same group of teachers have worked to employ similar assessment techniques and to weigh them in a similar manner. This provides a level of consistency in regards to assessment throughout the school.

For several years, Andrea has been a member of an informal group of female math teachers spanning from the elementary to the high school level. This "study group" has been very informative and supportive as Andrea has attempted to use alternate assessment techniques. She was particularly impressed with the elementary and junior high teachers who appear to be "ahead of us on the assessment game." She believes that they are not driven in the same way by curriculum and that "there's a little more freedom in how you choose to put it (curriculum) together, and get at the concepts." She doesn't believe the same level of freedom exists at the high school level and suggests this lack of freedom, as well as time, impedes the adoption of alternate assessment techniques.

### (3) Master Level Courses

Although Andrea didn't mention whether any of her graduate level courses concentrated in the area of assessment, she did state that the assessment was regularly discussed. Andrea was particularly fond of the work of one professor who specialized in the area of problem solving. He tried to show that "so much more comes into play than just answering (problem solving) questions." One should not merely assess the final answer but also assess the strategies employed, the reasoning, and the perseverance displayed by the student. Insight into student understanding went well beyond the final answer.

#### (4) Inservicing

Andrea was concerned by the lack of attention the Department of Education spent on assessment practices. She feels that teachers were left with little direction. It was only through working collaboratively with teachers from different levels and from different schools that she has able to make changes in her assessment practices. She does acknowledge that the board-wide H.R.S.B. inservice on the Grade 10 linear programming unit was the one exception to this problem. The inservice provided an introduction to how the discovery curriculum could align nicely with alternate assessment techniques. Andrea saw how assessment could be activity based. Unfortunately, this type of inservicing was not followed up, leaving some with the feeling that they must fend for themselves.

Andrea raised another concern regarding professional development practices of the Department of Education. It stemmed from the Department's choice to use the train-the-trainer model. With this model, an expert typically from the Department conducts an inservice for a select group of teachers representing different regions of the province. They are typically provided with two days of intensive professional development on a particular topic. After that time, they are expected to return to their region and conduct inservices for the other teachers in their area. Andrea contends that this is problematic since the new trainer has not been provided with enough time to reflect upon and reinforce the new concepts that were presented before conducting their own inservice. Ultimately some of the message is lost by the time the ideas are presented to the regular classroom teacher.

#### (5) Andrea's Comfort Level

Andrea recognizes that her comfort level with certain assessment practices influences whether that practice is incorporated and/or the degree to which it is incorporated. When she feels that she possesses the necessary background regarding the practice, she is willing to try using it. The decision to continue using the practice appears to be governed by her confidence in her own ability and/or the presence of ongoing support using that technique.

*Summary.*

Andrea is pleased with the changes she has made in her assessment practices and the rationale she has used in selecting these alternate practices. She believes that these practices fit nicely with the new curriculum but recognizes that there is always room for improvement. If she was required to make additional changes, she believes that several issues must be addressed by the Department of Education. Andrea is concerned that the issue of limited classroom time affects her selection of assessment items. Andrea, as well as her students, are in a situation which demands that they all use their time wisely. Large class sizes, a semestered system, occasional school cancellations, and time-intensive curriculum make it exceedingly demanding for all concerned. Everyone must remain focused and on task because there is little time for diversions, educational or not. Andrea feels that the Department should provide more class time so that assessment practices, as well as teaching practices, can change and improve for all teachers. Andrea also stated that research supporting the use of a particular assessment technique should be provided to teachers. She feels that teachers would be more likely to try a particular form of assessment if they understood the rationale and benefits for using it. This is typically not done with publications from the Department or supplied during inservices. Andrea's last concern dealt with the lack of exemplars. Teachers need to see assessment items that work, and clearly understand how they are used and why they work. If these are provided then Andrea believes that they can serve as a template for developing similar assessment items.

## *Craig's Story*

### *Craig's conceptions of mathematics.*

When asked about his concepts of mathematics, Craig stated that mathematics was analogous to philosophy. He believes that mathematics, like philosophy, is built on logic in which one examines and manipulates the relationship between cause and effect.

I would probably be most comfortable comparing mathematics to philosophy. That would be the closest that I could have. A philosophical argument is an argument based upon cause and effect, . . . , there must be a logical base between the cause and the effect. I think in mathematics, we feel the same way. If you have a cause, then there is usually an effect at the end.

Craig takes this further and demonstrates how this analogy can be used to describe problem solving, an integral part of mathematics by his own description.

Problem solving is based upon a series of logical arguments, and each one of these logical arguments has to be interconnected to the next one, and the one before it must fit with the one after it, so mathematics to me is very similar to what I see a philosophy is. The statement before must be connected to the statement after, the statement after, and everybody has to fit together for a philosophy.

Craig also inferred that mathematics has a level of practicality and relevance that one should be exposed to and learn to appreciate. This factor was identified when Craig discussed the types of topics he supplements the curriculum with, when time permits.

Later in the interview, Craig mentions another factor that helps define his conception of mathematics. He states "that students learn best when they do for themselves." He recognizes that the logic and understanding required in mathematics is obtained by being an active participant in the discipline.

Craig's conceptions of mathematics can be summarized by the following. Mathematics is a series of interconnected concepts, many with real world significance, bound together by logic in which one must understand how these concepts fit together. This understanding is only reached when one actively participates in mathematics and explores each of the concepts.

*Craig's teaching practices.*

Craig states that there was a very strong alignment between his conceptions of mathematics and teaching practices about 10 to 15 years ago. At that time, the curriculum and assessment policies from the Department of Education and his own board were more flexible. He felt that there was some latitude in the type of curriculum he had to deliver and similarly some latitude in how it should be delivered. Craig stated that "I knew what was important at each grade level for kids, and I tended to teach that to them." For example, he discussed one of the major topics he used to teach in his Grade 11 academic course many years ago. His students would spend about two weeks in a nonsemestered system learning how to complete income tax forms. He believed that this practical application of mathematics was extremely beneficial to his students as a life skill, but also fostered their literacy skills, as they were required to read and follow numerous sets of directions. Even 20 years later, Craig encounters former students who inform him that these

income tax lessons were "the most valuable thing that they ever learned inside a classroom." The flexibility, and the greater instructional time, allowed Craig to go beyond the prescribed curriculum and include topics that complimented his conceptions of mathematics.

Craig was clearly dismayed when stating that today the alignment between his conception of mathematics and his teaching practices is not as strong. He feels that he has become so conscience of the curriculum, the time constraints, and the Board's assessment policy, that he systematically delivers the curriculum with little time for complementary materials.

Over the last seven to eight years, I think I've become very linear in the teaching. We have a series of outcomes now that each kid has to master, each grade level and each course, and I've become very, very conscious of those outcomes, and almost check them off in an organized way.

However, Craig is pleased that his present teaching practices are centered around discovery learning where each student is required to explore and understand each new concept. Often this means that student must work cooperatively in groups. He acknowledges that he has made significant progress in this area over the last ten years and is very satisfied with the learning environment that has been created in his classroom.

I think that if you were to look at the classroom that I'm in today, you'd probably see the true, so-called constructivist classroom, where the kids are allowed to explore concepts on their own. They form opinions, we share ideas, and I try very hard not to be much more than a mentor, where at some point in the lesson, I try to help the kids bring all the ideas together, and bring the lesson to a closure where we all walk away with a similar sense of meaning of the topic.

Craig's teaching practices have changed over his career, most strongly influenced by the implementation of new mathematics curriculum, and by watching his own children as they went through the public school system. Only over the last ten years has Craig realized that students learn best when they are active participants in the discovery process. This revelation occurred when Craig started to incorporate many of the investigations recommended in the new curriculum. A similar revelation occurred as he watched his own children grow and navigate the public school system.

I watched the way that they learned, and I watched the way various teachers taught them over the years, and I began to realize that kids learn best when they learn on their own, and as I watched them grow, I think that my own teaching style has drastically changed, and I think it has a lot to do with the fact that I'm a parent of two kids that went through the public school system

As previously mentioned, Craig's teaching practices were also altered to align with the new outcome-driven curriculum from the Department of Education and to align with the time constraints associated with semestered schedules. The lack of flexible meant that his focus was to insure that he had addressed all of the outcomes. Exercising professional judgement in the delivery of curriculum was reduced significantly.

*Craig's views on assessment.*

When asked what assessment meant to him, Craig stated that assessment is the "global picture" of where the student is as a learner. This means that he examines all of the evidence gathered

from exams, tests, quizzes, assignments, projects, probes, and independent study units and uses this information to determine a student's understanding of the mathematical concepts covered in the course. It should be noted that throughout the interview Craig focussed on formal assessment practices. Craig viewed evaluation as a process of "evaluating what you (the student) learned today." This means that all of these small forms of evaluation are used to formulate the "global picture" of assessment.

When Craig was asked about the types of assessment practices he had heard of, he provided an extensive list and informed me that he had attempted to use all of this, some which he later abandoned. He provided the following examples of assessment techniques in this particular order.

(1) Tests

Craig's tests are designed to be completed within 80 minutes. He makes sure that these tests are comprised of level 1, level 2 and level 3 questions as specified by the Department of Education.

(2) Quizzes

Craig's quizzes are designed to be completed within 10 to 15 minutes. These frequent, yet brief, forms of assessment are graded by the teacher and provide feedback to the student regarding concepts they are presently working on.

(3) Probes

Craig uses probes two or three times during a two week period. Probes are very short quizzes that are designed to see if the students understand the concept or concepts

covered in the last two or three days of classes. They are designed to be a non-threatening form of assessment that provide immediate feedback to the student as well as the teacher as to the level of individual understanding. If a problem can be identified early, the teacher can immediately implement changes in an attempt to alleviate the problem. The probe that follows can be used to see if the teacher's intervention was successful in addressing the earlier diagnosed issue. In order to insure immediate feedback, Craig often has students exchange papers and evaluate a fellow classmates work (i.e. peer evaluation). On these occasions he insists that students provide written feedback to their classmate, rather than merely marking a solution incorrect.

#### (4) Assignments

Assignments are given near the end of a unit and provide a comprehensive overview of all topics found in that unit. The students are given the assignment 3 to 4 days prior to the due date. Craig's expectation is that the assignment will require a least 3 to 4 hours of steady work to complete.

#### (5) Independent Study Projects

Independent study projects are designed collaboratively with other teachers in Craig's mathematics department. The assigned materials are typically gathered from a variety of resources, rather than using items found in the prescribed textbooks. The students are given four weeks to complete the project and their mark is comprised of three components. One component is a quiz that occurs two weeks into the project. This quiz insures that students have started the project, and are working through it in a timely manner. Another component of the mark is obtained from a test that is written at the end of the four week period. The last component is based on the

completion of all of the assigned questions. For the Math 12 and Math 12 Advanced courses, the independent study project deals with permutations, combinations, and probability. For Craig's PreCalculus classes, the independent study project covers sequences, series, and complex numbers.

(6) Literacy Assessment Items

Craig uses and encourages other colleagues to use literacy items on their tests and exams. Presently all of his tests have at least one of these questions and his final exams have at least two or three of these items. From Craig's perspective, mathematical literacy questions encourage students to display a level of understanding not restricted to mathematical symbols.

(7) Exams that include a Collaborative Component

Craig used to have an entire day allotted for each of his classes for their final exam. During the morning, Craig's students completed a traditional final exam. However, during the afternoon, students worked in groups of three, chosen at random, on three problem-solving questions that aligned with the curriculum. This collaborative component was worth 25% of the total exam mark.

(8) Homework Checks

Originally Craig checked to see if each assigned section of homework was completed, however, in recent years, he has had students hand in one or two questions from the assigned homework to be marked.

(9) Portfolios

Craig did not provide any description of this particular assessment technique.

*Assessment practices that Craig has used.*

Craig supplied nine different assessment practices that he had heard of, all of which he has tried at some point in time. The two he is presently not using are exams that include a collaborative component and portfolios. The decision not to use exams that include a collaborative component is tied directly to the mandate from the Department of Education to allow schools only four days per semester for final exams. When schools attempt to schedule internal, as well as external (i.e. provincial) exams, there is little time left to consider an exam that requires a full school day to complete. Such was the case with Craig's exam. Craig was disappointed with this mandate and the resulting implications to his mathematics courses.

The other thing that I've lost that really upsets me, is since the province has become so widely involved in assessment that we have the Grade 12 assessments, and we're only allowed four days to do it, so that removes a lot of room in your schedule for doing different types of assessment. . . . I'm using someone else's prescribed routine, and I've lost that flexibility of being able to do my own assessment.

Craig has tried using portfolios at least seven or eight times. Each time he had felt that this form of assessment didn't tell him anything new about the level of student understanding. He was also disappointed with the quality of the work submitted. "Some of it's good, some of it's bad." Unfortunately he felt that he ultimately ended up with a filing cabinet filled with "an awful collection of our material." It should be noted that Craig was not concerned with the time required to complete and review portfolios, rather the relevance of this form of assessment and the quality of student materials produced.

Craig's homework checks have undergone a major revision in the last few years. Based on the assessment policies of his Board and those from the Department of Education, Craig is unable to allocate a percentage of the student's mark for the completion of homework. The argument from these organizations is that marks should only be awarded when a student demonstrates the successful completion of a specific curriculum outcome. They contend that checking to see if homework is complete does not insure that any outcome has been met. Craig is unhappy with this restriction believing that the checking homework daily is "one of the best motivators" we have in mathematics. In an attempt to adhere to the new policies and still encourage students to complete homework, Craig has students regularly submit one or two homework questions. These solutions will be marked and returned. All of these homework responses will ultimately be worth 10% of their final mark.

In terms of the assessment practices that Craig uses, the selections and percentages allocated to each are largely based on Board policy regarding assessment. As previously mentioned, he feels that these "dictatorial" policies restrict his opportunities to apply alternate assessment practices. Presently, Craig uses tests, homework assignments, major assignments, independent study projects, quizzes and probes. The percentages allocated to each are shown in the table below. It is important to remember that thirty percent of the final mark is based on the Grade 12 external exam.

Assessment Practice	Percentage of Term Mark
Tests	30%
Homework Assignments	10%
Major Assignments	20%
Independent Study	20%
Quizzes	12%
Probes	8%

In terms of the literacy assessment items, Craig incorporates this form of assessment in his tests and exams.

*Changes in Craig's assessment practices.*

When Craig was attempting to describe the changes in his assessment practice, he described these changes in terms of three different phases. In phase one, when he was a young teacher, 60 to 70 percent of a student mark was from quizzes and tests, with the remaining percentages based on assignments and projects. In phase two, the middle of his career, he incorporated cooperative assessment, homework marks, and literacy items. This was the phase that he was most proud of. In the third phase, the last few years, he has been restricted to a "very formal (assessment) structure" defined by the Halifax School Regional Board. He has followed the Board's policy, however, he's "not quite as happy" with this new direction in formal assessment.

Craig identified several factors that were instrumental in changing his assessment practices.

(1) Course Work

Craig had taken several courses that had examined how children learn mathematics. Components of these courses focussed on assessment techniques. It was during this time that he realized that limiting himself to tests, quizzes and assignments really didn't allow all children the opportunity to express what they knew about mathematics. This was instrumental in moving Craig from phase one to phase two in terms of assessment practices.

(2) Professional Interest

Prompted by the course work, Craig continued to research assessment practices. He searched the internet and read numerous NCTM articles. Armed with this new information and that which was acquired from the course work, he started to implement changes.

(3) Time Factors

Craig stated that time restrictions were key factors in his decision to use or not to use two assessment practices: exams with a collaborative component and independent study units. As mentioned earlier, the decision by the Department of Education to restrict the testing period for final exams to four days within a school, was critical to Craig's decision to eliminate the collaborative component on his final exam. He firmly believed in the value of this collaborative portion of the exam and was disappointed when he had to terminate it based solely on this policy from the Department. Craig's decision to incorporate the independent study project was partially motivated by the restrictions in instructional time created by a semestered

system and an outcome-driven curriculum. Craig felt that the independent study project provided additional time so that he could complete all of the prescribed curriculum. Craig's feelings regarding the time restrictions are best described by the following statement.

The curriculum is very tight in terms of the number of outcomes that we try and cover. There's not quite the maneuverability and time there was years ago to deal with kids in the same way. I find it difficult to fit the extras in.

#### (4) Mandated Changes

In an attempt to insure that assessments were fair, the Department of Education stated that final exams were not to exceed 30% of the final mark. The Halifax Regional School Board had similar concerns in regards to assessment practices and implemented a policy restricting the percentages allotted to tests and quizzes. As previously mentioned, Craig felt that this board policy restricted some of the alternative assessment practices that he had already implemented. This frustration with the Board policy was troubling for another reason. Craig had served on the Board's assessment committee and felt that many of his suggestions had not been adequately considered.

#### (5) Dialogue with Other Teachers

Craig felt very fortunate to have "always worked in an environment where teachers work collaboratively together" and to have worked in schools that would be viewed as "progressive." For example, he believes that his present school is considered a "leader in terms of literacy and numeracy across the curriculum." Craig prefers to surround himself with highly motivated mathematics teachers, and avoid those who

are consumed with the negative aspects of teachings. By doing so, he believes that this collaboration has resulted in the development and implementation of innovative and functional assessment practices.

#### (6) Assessment Practices Used at Post-Secondary Institutions

Since a significant number of Craig's students would eventually be going to university, he felt that some of his assessment techniques should parallel those used at university. For this reason, he always requires his students to complete a multiple choice component on their tests and exams. Many university exams have multiple choice sections and Craig felt that his math students would be well served if they had prior experience with these types of questions.

Although Craig recognized the influence of post-secondary assessment practices on his own assessment practices, he was clear that he was not going to endorse all of their assessment policies. For example, he was unhappy with the university practice of not allowing graphics calculators on tests and exams. He was also troubled by the practice of basing the majority of the mark on a few tests and a final exam.

Craig did identify another factor that could affect the types of assessment practices used within the province of Nova Scotia. Although this factor hadn't yet affected his own practices, he recognized that it may have some influence in the future. The factor was the teacher inservicing model, "train the trainer" used by the Department of Education. Under this model a small group of teachers from around the province are brought to one location and given an intensive one or two day workshop on a specific topic. After completion of the workshop, these participants are now considered leaders who will return to their boards and disseminate the newly acquired information to other teachers via smaller workshops. Craig is adamantly opposed to this

inservicing model for it demonstrates that the Department is only paying "lip service" when it comes to the issue of teacher support.

The Department of Education has itself fooled into thinking that they can produce so-called experts in every school board, and then they will go off and dissipate the information; it doesn't work. We cannot make experts in one day, who will then go off and trade it with another 30 or 40 people.

However, Craig is convinced that if the inservicing model is changed to an ongoing, long term inservicing model, it will have a positive effect throughout the province. Under this new model, teachers would have opportunities to work closely and over a much longer period of time with a true expert in the specified topic.

*Summary.*

Craig is generally pleased with the assessment practices that he uses today but does have some regrets regarding the elimination of the collaborative component of his final exam and the changes he had to make regarding his homework policy. Although Department and Board policies, coupled with tight time constraints and outcome-driven curriculum, have made Craig's job far more demanding, he is content with the direction his assessment practices have taken. He feels that there is a strong correlation between his teaching practices and his assessment practices and that his students are fully aware of this correlation. His students understand that the work that they are challenged by on a daily basis, reflects the types of questions they will ultimately face on their formal assessment. Craig feels that his assessment practices align with those defined by the Department and Board. This is an important issue for Craig because as a former

Department Head and senior teacher on staff, he believes that he should serve as a good example for other teachers in his school's mathematics department.

### *Ryan's Story*

#### *Ryan's conceptions of mathematics.*

When asked about his conception of mathematics, Ryan proposed that mathematics is a series of interconnected topics taught in an incremental fashion. As one learns new concepts and strategies, one is more likely to solve a greater variety of questions. This understanding of the "basics" is critical to developing an overall understanding of mathematics.

I view math as a subject that needs to be taught in small pieces before you attack a bigger problem and students need to be shown that the basics lead to solving difficult problems. I went towards math because I saw that it was very sequential in nature. Even the toughest problems could be solved by understanding the basics. I had some math teachers that were not great math teachers , not great mathematicians but taught us that the basics lead to solving problems.

Ryan also viewed mathematics as an area of study that can be applied to other disciplines. For example, Ryan understood the rationale for teaching exponents and logarithms as they have numerous applications in chemistry, physics, and business. He believes that these sorts of applications are the fundamental reason for learning mathematics.

Ryan viewed mathematics as one of the few disciplines that generally has one clear answer to a specific problem. Working with these absolutes brought Ryan satisfaction when completing questions.

I liked the science courses opposed to the writing courses. I also gravitated to math because when you found the solution you could always check your answer to know if you were correct. So I guess it was a prize at the end of (the problem). (It provided) satisfaction that the work you did was right.

This level of satisfaction associated with Ryan's study of mathematics extends to his teaching of mathematics. Since in many cases, problems have only one final answer and can be obtained by a few strategies, the teacher can monitor his students and quickly ascertain their level of understanding. This means that intervention can take place much more quickly than in other disciplines.

One of the reasons for choosing math was that it was a topic that you immediately knew whether or not the students picked up what was being taught. Because if they couldn't do the work you could reteach it now and not in a month. That was one of the reasons why I like math.

Ryan's conceptions of mathematics can be summarized by the following. Mathematics is a series of interconnected topics bounded by understanding of the basic fundamental concepts of mathematics. There is also a level of practicality to mathematics as it has numerous applications to other disciplines. Since many mathematical problems require that one works with absolutes, this can provide a level of satisfaction for those wishing to master these basic concepts.

*Ryan's teaching practices.*

Ryan's conceptions of mathematics have influenced what material he has taught and how that material has been taught, however, he is careful to stay within the defined outcomes in the curriculum. As previously mentioned, the connections between mathematics and other areas of study are fundamental in Ryan's conception of mathematics. When teaching new concepts, he takes every opportunity to show the rationale for mastering a concept especially how it applies to another discipline. For example, he demonstrates how algebraic skills are required for those individuals interested in pursuing accounting or how statistics can be used to predict the spread of a pandemic flu. Incorporating real-world applications is a critical component of Ryan's teaching.

When I am teaching something I always try to tell the students the reason for learning this topic today so that it will help you do this following topic later on. For instance when we are doing statistics, we taught about actuarial science and when there was an article about the pandemic that is going to be coming for the flu, how is that predicted?

Ryan believes that mathematics is a series of interconnected topics taught in an incremental fashion, and this is reflected in his teaching practices. When teaching a new concept, he insures that the lesson is punctuated by questions that encourage reflection on the part of the student. These questions may be oral, may require a written response, or may be a traditional exercise question. Regardless of the type of question, they do force the student to reflect upon what he/she has been taught. If the student is struggling with the concept, intervention can take place to remedy the situation. Understanding the "basics" is critical to having a broader understanding of the topic and ultimately being able to handle more challenging questions.

Ryan's teaching practices have changed over his career and he attributes these changes to three factors; experience, graduate level courses, and curriculum changes. In the beginning of his career, Ryan would teach complete lessons and then assign the work, some of which had to be completed at home. With experience, Ryan learned "to listen to the students." As previously mentioned, he concluded the lessons with reflective questions. This gave the students the opportunity to voice concerns or seek clarification. This dialogue became an important component of his daily teaching practices.

In the early 1990's, Ryan completed his Master of Education degree and a significant portion of his time was spent examining cooperative learning and learning styles. Most of his education professors had extensive classroom experience and they expounded the virtues of cooperative learning. When Ryan returned from his studies, he made group activities an even greater component of his teaching practices. However, his graduate courses did stress that every student has a unique learning style and that using cooperative learning as the sole means of curriculum delivery can be detrimental.

Early in Ryan's career, the Math 431 and 441 programs were introduced. These programs stressed problem-solving as a primary component of instruction. Ryan has influenced this new curriculum and attempted to incorporate problem solving into other courses he taught. Within the last five years, a new secondary curriculum that stressed discovery learning was introduced throughout the province. Ryan's teaching practices changed to reflect these curriculum changes, however, he had mixed feelings about this. Although he saw the value of discovery learning, he felt that the province was adopting this teaching practice at the expense of others. Little value was shown to more traditional teaching practices and he felt that this may ultimately be a disservice to some of the students we teach.

Discovery has its place but only for certain students, just as rote learning has its place for only certain students. I think the class has to have a combination of rote, exploration and summarization where the summarization comes from the teacher or the students. But to only do exploration in the curriculum where teaching is too time consuming to do all of the topics through exploration (can be problematic).

These misgivings were supported by what he had learned in his graduate courses.

*Ryan's views on assessment.*

When asked what assessment meant to him, Ryan responded that assessment can come in many forms and should be designed "to see what they (the students) can and cannot do and teach to what they don't know." Another important feature in Ryan's definition of assessment is that it should provide feedback to teachers, students and parents in a timely fashion. This means that there are many occasions when Ryan will stay up late correcting quizzes and tests so that they can be returned to his students the next day. Unfortunately, he feels assessment means something else to parents and students. For many students and parents, assessment equates to marks. They appear to focus on the mark and how it affects the student's acceptance into post-secondary institutions, rather than as a mechanism to understand the level of student understanding.

Ryan recognized that there are informal forms of assessment such as monitoring students as they complete assigned work. This allows Ryan to immediately alter his lesson if a problem regarding student understanding is identified. It also allows for intervention on behalf of an individual student if he/she is struggling with a concept. Ryan doesn't feel pressured to give marks for all forms of assessment. As he pointed out, sometimes assessment is just to understand "who knows how to do it and who doesn't." His last point regarding assessment was

the difference between authentic and non-authentic forms of assessment. Authentic forms of assessment are those that clearly identify whether a student can meet a specific outcome. Non-authentic assessment are not directly tied to an outcome. For example, checking to see if homework is complete is considered non-authentic because the teacher has not checked the individual solutions to determine whether the concepts are or are not being understood.

When Ryan was asked about the types of assessment practices he had heard of, he provided an extensive list and informed me that he had attempted to use all of this, some which he later abandoned for a variety of reasons. He provided the following examples of assessment techniques in this particular order.

#### (1) Monitoring Student Progress During Class

Interestingly, Ryan was the only participant to mention this as the first form of assessment. The other participants initially focussed on tests and quizzes. Ryan stated the following.

You set your daily assessment in the classroom where you walk around and observe the students at work, and answer questions for them or direct them towards solutions.

In addition to identifying problems, Ryan uses this opportunity to examine the range of strategies students employ to solve questions. With this information, Ryan will often ask students to demonstrate their solutions to the class.

## (2) Checking Homework

Homework is checked on a regular basis and a small portion of the term mark is based on the completion of homework.

## (3) Quizzes

Quizzes occur at the end of each week or at the end of the seven day cycle. They are usually comprised of two questions, one that might be a series of multiple choice questions. Since the quiz is quite short, Ryan is often able to return the corrected quizzes prior to the end of class. If not, the quizzes are returned the next day. Ryan feels that quizzes not only inform student's of their own understanding but also provide opportunities for growth. For this reason, Ryan encourages his students to rewrite quizzes that they performed poorly on. If they choose to do so they cannot receive a mark greater than 70% on that quiz even if they completed all the questions on the retest correctly. Ryan feels that the students really "appreciate the fact that they get a chance to catch up."

## (4) Question Assessment

This is a form of informal assessment where Ryan asks his students to turn in their scribbler to a particular question that they have previously attempted. He quickly walks around the room, observing their solutions, and decides if his lesson should be altered if students are struggling with this particular question.

## (5) Tests

At Ryan's school, it is policy to have at least one test per month. Ryan ensures that there are a variety of questions at different levels of difficulty.

I like the idea on any given tests 50% of it should be things that we drilled or practiced or come naturally. 30% would be called your secondary level questions and 20% of the questions should be questions that you do not expect all of the students to answer.

Secondary level questions are often application questions or questions which require students to work between different representations (graphical, written, algebraic, geometric, . . .). Ryan's last 30% could be best described as challenging problem solving questions that are extensions of concepts covered in class. Ryan also stated that test should be "cumulative in nature." This means that a test should not focus just on concepts covered in the last few weeks. It should also draw from concepts learned earlier in the course. When marking tests, Ryan believes in correcting one question at a time for an entire class set. Not only does it provide consistency, but it makes it far easier for Ryan to identify common misconceptions among his students.

#### (6) Open-Ended Questions

Ryan defined open-ended question as those that "give the students the opportunity to create a question that had an answer that relates to a formula I might have given them. I could give them a final answer and then say, create the question that this is the answer for."

#### (7) Extension Questions

From Ryan's perspective, extension questions came in two forms. The first were questions that were "related to a couple of topics we did in class but they had never seen the question before." These questions involve multiple concepts and stress the interconnectiveness of math. The other type of extension problem involves taking a

concept that applies to a problem at this grade level and use that same concept to address a problem associated with a higher grade level. For example, if you have been working with a concept associated with quadratic functions, one can create a question associated with cubic functions, a PreCalculus topic. When it comes to these challenging extension questions, Ryan has "always believed that the most difficult questions should be worth the least" in terms of point value.

#### (8) Cafeteria Testing

This form of assessment was developed at Ryan's school. Periodically students are given a 50 point test where 30 points are derived from a series of questions of varying levels of difficulty and point values. More precisely, there are three questions, each with a part (a), (b), and (c), worth 6, 8, and 10 points respectively. The 6 point questions are more procedural in nature while the 10 point questions are problem-solving questions. Students choose one part of each question to complete. If a student chooses part (a) from the three remaining questions, the maximum mark he/she can obtain is 38/50 (76%). If a student chooses one part (a) and two part (b)'s, the maximum mark he/she can obtain is 42/50 (84%). Since the student is choosing the type of question that they wish to complete, Ryan and his colleagues equated it to selecting items at a cafeteria.

#### (9) Mathematical Literacy

Prior to tests, Ryan asks his students to collect and complete a series of review questions of their own choosing. One of the components of this review is that students must also provide written explanations for each of their questions identifying

what was done and the rationale for doing it. Ryan pointed out that students "need to learn the mathematical language."

(10) Reflective Self Assessment Prior to Test (i.e. Student Review)

As mentioned in the previous assessment technique, Ryan has a unique and innovative method to have students review for tests. Although it has a literacy component, it can also be viewed as reflective self assessment. Students are asked to examine concepts previously covered, reflect upon their own knowledge of these concepts, select/create a series of review questions, and complete these questions. This process forces students to examine their own knowledge and, in some cases, initiate their own remediation. It is a four step process to get students to this point. Initially Ryan makes up a review sheet a week prior to the test and asks that his students complete it and hand it in before the test. For the next test, Ryan initiates a class discussion where they collectively decide upon a series of review questions. The selected questions are written on the board, the students copy them down, and they complete them prior to the test. The third step in this process occurs prior to the third test. Each student is asked to pass in a series of review questions. These questions are examined by Ryan who later reports back to class informing them of their selections. Before the third test, students are required to complete their own review questions and any other they deem pertinent based on Ryan's report. The final step in this process occurs prior to the fourth test. Each student selects their own review questions, completes them, and provides written explanations for each.

*Assessment practices that Ryan has used.*

Ryan supplied ten different assessment practices that he had heard of, all of which he has tried at some point in time. The only one he is presently not using is cafeteria testing. He and his colleagues had used this type of testing in the past and he felt that it was "very successful", however, the implementation of the new curriculum impeded the use of this form of assessment. Discovery learning was an integral component of this curriculum that required additional class time compared to a more traditional lesson. Ryan and his colleagues felt that there was little time left for this type of testing. It should be noted that they are going to attempt to reintroduce this form of assessment next year.

Ryan's homework assessment has changed over his career. Prior to working at his present high school, Ryan worked at a smaller rural high school where students were not regularly completing homework. This meant that students were having difficulties completing the prescribed curriculum. Ryan, with the support of the principal, took the drastic measure of making homework 70% of the term mark. Students started to do their homework and discovered that homework, like class work, had value. This policy remained in place for a two year period, then homework was reduced to 50% of the term mark, and eventually to 30%. The math department at Ryan's current high school presently allots 7% of the term mark for homework. Although Ryan agrees that a portion of the mark should be based on the completion of homework, he feels that 7% should be increased 12%. From Ryan's experience 12% seemed to be the value that worked for the students and himself.

*Changes in Ryan's assessment practices.*

Ryan cited several factors which influenced him to make changes in his assessment practices.

(1) Experience

Ryan stated that after several years, he learned to listen to his students. Their responses and comments were integral to understanding their level of understanding or sometimes lack of understanding. He acknowledges that his informal assessment practices improved with time. Ryan has also spent time working in the school's learning center. In this environment, he discovered that many students possess "a lot of knowledge which needs alternative assessment methods." Relying on traditional tests and quizzes does not suffice when trying to understand the level of student understanding, particularly when dealing with students in the learning center. Ryan elaborated and stated that his school's center often serves students whose second language is English. For these individuals, tests comprised of application questions and/or questions that require written explanations can be problematic. Flexibility is required to insure that the assessment techniques do not penalize students because of their lack of understanding in an area other than math.

(2) Dialogue with Other Teachers on Staff

The classrooms for the mathematics teachers at Ryan's school are all located in the same area of the school. The teachers do not have to travel far to meet with any other teacher in the department. This encourages discussion and collaboration amongst the mathematics teachers. This dialogue often breeds innovation both in teaching and assessment practices. Ryan credits many of these innovations to one mathematics teacher on staff, particularly in the area of assessment. This teacher has always advocated that tests be comprised of questions ranging from easy to difficult and that problem solving should be an integral component on each test. He was also responsible for developing the cafeteria testing that Ryan found quite successful.

### (3) Graduate Courses

As previously mentioned, Ryan completed a Masters of Education degree at the University of Maine and a significant portion of his time was spent examining learning styles. This experience, coupled with his experience in the learning center, reinforced the notion that a variety of assessment strategies should be employed to address a wide variety of learning styles. In another course, Elementary Problem Solving, Ryan had the opportunity of seeing the benefits of having students reflect upon each days lesson. His professor would often ask his students, Ryan being one of them, to reflect upon the lesson and write a brief response as to the purpose of the lesson. From Ryan's perspective, he was surprised by the range of the responses. The purpose of the activity often varied from individual to individual. This diversity frequently provided insights into levels of understanding and misunderstanding. For this reason, Ryan returned from his studies and employed this assessment practice in his classroom.

### (4) Curriculum Changes

In Nova Scotia, curriculum was formerly defined in terms of mathematical concepts, rather than outcomes. The emphasis was on the successful completion of a series of mathematical topics that relied heavily on algebraic techniques. With the implementation of the A.P.E.F. curriculum, the focus changed to developing an understanding of interconnected mathematical concepts. Ryan recognized that his assessment practices had to change such that they would compliment this new curriculum.

### (5) Self-directed Professional Development

Ryan stated that articles he read in N.C.T.M. publications, as well as workshops that he selected at conferences, had affected his selection of assessment practices. Ryan did not, however, elaborate further on the extent or nature of their influence on his practices.

(6) Number of Different Courses Taught

Presently Ryan works in a large high school where he is required to teach only two different courses a year. This contrasts with the teaching assignments at smaller high schools, he had earlier in his career. These earlier teaching assignments often required that he teach four or five different courses during the same time period. Ryan recognizes that reducing the number of different courses taught does have benefits to both the teacher and students when it comes to assessment practices. With fewer courses, a teacher can devote a greater portion of time to developing and/or improving assessment techniques.

(7) Using Assessment to Change Student Work Habits

As previously mentioned, Ryan altered his homework assessment practices to encourage students to complete and correct assigned homework.

Ryan is satisfied with the assessment techniques that he uses, however, he is eager to learn new practices that would benefit his students. Not only does he want to learn of alternative practices, but he feels that it is imperative that he views these practices in action in a real classroom setting and understand the rationale for using such a practice. He does caution, however, that these new assessment practices should not replace more traditional practices, rather they should be applied concurrently, giving all concerned a greater awareness of student understanding.

I look forward to be shown how to do the assessment. I'm always open to new ideas. I don't think you need to throw the baby out with the bath water though. . . . If somebody comes up with other methods of assessment, I'm willing to use them. . . I'd like to see

some examples that are being used. I'd like to, in some cases, observe someone using the type of assessment if it's something very new. I'd like to know the reason for using it

Ryan views the implementation of the external exam for Math 12 Academic and Math 12 Advanced courses positively. It forces teachers to "care about what they're teaching" and "forces everyone to try to reach a certain level." These exams identify minimum standards for these courses and should provide some consistency in curriculum delivery and assessment practices throughout the province. Ryan's only reservation regarding the external exams focused on the lack of truly "novel" questions. He feels that the problem solving or level three questions are noticeably absent on the exam and that this deficiency should be rectified.

*Summary.*

Ryan is satisfied that there is alignment between his teaching practices, assessment practices, and conceptions of mathematics. There is enough flexibility within the curriculum and within the school's math department such that he can teach and assess in a manner that supports his own philosophy regarding the teaching of mathematics. He believes in discovery learning, but if Ryan perceives that a particular activity doesn't adequately address a specific concept, he will alter it or replace it with another discovery activity. If he believes that a concept should be introduced using a more traditional lesson, then he will initiate this change. If he thinks that a particular concept should be examined in greater detail, then he will obtain or design questions that require further examination of the topic. Ryan believes that his freedom to exercise professional judgement has been beneficial to both him and his students, yet he has consistently addressed all the outcomes outlined in the provincial curriculum documents.

### *Denise's Story*

#### *Denise's conceptions of mathematics.*

Mathematics from Denise's perspective is about understanding concepts, where these concepts come from, and why they are important both in mathematics and in other disciplines.

Mathematics requires one to be flexible in one's thinking as there are often multiple strategies that can be employed to solve a particular problem. She does not view mathematics as a static, rule-driven discipline. Mathematics and the problem solving associated with it provides enjoyment to Denise, however it is not all-consuming. She said, "I enjoy it myself", however, "I have other things that are more important to me, like my family."

#### *Denise's teaching practices.*

Denise's conceptions of mathematics do influence her teaching practices but not in all cases.

Teaching for understanding in a manner that best serves the needs of her students is imperative to Denise. Denise is willing to try alternate teaching strategies, however if she ultimately finds that these strategies are not benefiting the students and are not supporting her fundamental conceptions of mathematics, then she will return to original practices. Such is the case with the current A.P.E.F. curriculum. She initially adopted the discovery learning approach endorsed by this curriculum but found she lacked the time and the students lacked the initiative and maturity to insure successful implementation. Although the curriculum did expose her to new ideas, which she continues to use, she has returned in varying degrees to more guided lessons and/or scaffolded investigations. Even with these adjustments, her role, from her perspective, is to serve as a facilitator of learning where students must take ownership of their own learning. She does not feel that her role is to dispense all of the information to her students. The students are still required to be active participants and engage in a variety of thinking activities.

When the new program came in, I said I was going to teach it as the Department had intended it to be taught using the investigative approach. But I generally moved away from that. . . I wouldn't say back to my old way of teaching, teaching a topic and assigning questions using the concepts, but now I tend to lead them through these investigations because I just don't think there is enough information in some of the investigations and I don't have time in the semestered system. Many of the students whether they are high achievers or not, don't want to know why a certain algorithm works and they don't want to work through the investigations. Sometimes they find the investigations too monotonous.

Denise is troubled by the lack of time available in a semestered system where she must deliver a curriculum that she perceives is inundated with too many outcomes for the students who are presently in the class. She is dismayed that she feels forced to move from one chapter to another knowing that many of her students haven't grasped the basic concepts. This is clearly in conflict with her conceptions of mathematics. In the past, Denise felt that it was better to teach most things well, rather than everything poorly. Now she is compelled to abandon this philosophy. Denise believes that this is a major concern at the Grade 10 level partly because of the students who are taking the course.

I have a class right now with great kids and everything, but they're quite weak and I know I'm going to leave this chapter and I'm going to go on to the next one, leaving half of them behind. That's not the way I've always taught. I want them to do well. I think that the time factor and the fact that the students are missing skills forces teachers to feel inadequate.

Denise acknowledges that her teaching practices have changed significantly over her career. Initially she was "a rule oriented teacher" where she would present the concept and the method, and then ask the students to complete a series of similar questions where most relied on the same strategy. With experience, this practice was gradually abandoned in favour of one that centers on mathematical thinking and understanding, rather than algorithms. As she became more confident and comfortable in the classroom and in her teaching of mathematics, she felt that she could and should embrace the wide variety of strategies that may be employed to solve one particular problem. This can include strategies that employ concepts from other disciplines such as physics. With the introduction of the A.P.E.F. curriculum, she continued to adhere to these practices but also attempted to incorporate discovery learning into her lessons. As previously mentioned, this implementation was not entirely successful, so she did return to some of her practices of the past.

Several factors influenced the teaching practices that Denise chose, and in some cases, later abandoned. A few have already been discussed. She cited the lack of time in a semestered system, the initiative and maturity of students, and the implementation of the A.P.E.F. curriculum. There were other factors. Denise's initial "rule-oriented" stage was most strongly influenced by the teachers she had during her high school years. Her secondary education took place in a small rural school where all of her mathematics courses were taught by merely two teachers. Although these teachers were not particularly dynamic, they were very competent and knowledgeable. Their teacher-centered lessons delivered the curriculum in logical increments, however, the students took very little ownership in their own education. Denise stressed that she respected these teachers immensely so when she entered the classroom for the first time she adopted practices similar to their own. Unfortunately, embracing this teacher-centered learning left Denise with some disquieting feelings. Denise said, "When I first started teaching I thought that I had to be the one who dispensed this information and if they didn't get it, it was my fault."

Denise felt that she was almost totally responsible for an individual child's learning and that little responsibility rested on the child. After a few years, she gradually moved away from this, allowing students to take greater ownership of their own learning.

Dialoguing with other teachers was another important factor that helped shape Denise's teaching practices. She was particularly fond of the work that took place while on board committees. It was an opportunity to network with individuals from different areas who were using a variety of teaching strategies and materials. The collegial nature of these committees and the wealth of knowledge the members possessed was beneficial to all.

Denise mentioned that graduate courses had contributed to changes in her teaching practices. These courses had not subscribed to one specific set of teaching strategies, but rather exposed her to a variety of strategies that made her "open to new ideas." She left her graduate studies feeling that she did not have to go back to her "chalk and talk" methods of the past. There was more out there for her and her students to explore. Lastly, Denise stated that professional development days had also influenced her practices. When she attended conferences, she was fascinated "watching others teach." The actual material in the workshop was typically not as valuable as watching the presenter use a variety of strategies to deliver his/her message.

*Denise's views on assessment.*

Assessment, from Denise's perspective, involves a variety of techniques that a teacher uses to ascertain the level of student understanding and the type of reasoning students are engaged in. Not only should the assessment determine what an individual student might know and be thinking, but also identify problematic areas so that intervention can take place.

To me, if I'm assessing the students, I want to find out where they have gone wrong and that's a negative way of saying it, but I want to know where I can help them, and where they are making their mistakes. I want to help the class because if several people are making the same mistake, it's something that's going to be done over and over again for other students as well.

Throughout the interview, Denise continued to return to another critical component in her definition of assessment. This component was fairness. Using a particular assessment tool, even one that is highly regarded in educational journals, without considering the students in that particular class, can be problematic and unfair to those students. For example, Denise often has her students present projects or worked solutions, however, she will not engage in this form of assessment if a large portion of the class lack the confidence to present such materials.

Similarly, Denise believes that group assignments don't always serve the needs of weaker students. In groups of three or more, these individuals are often reluctant to provide input or ask for clarification. However, when these same individuals work with only one partner on the assignment or investigation, they are far more likely to participate. Group assignments that involve pairing appear to be a fairer form of assessment for some students.

Denise believes that evaluation should occur in a timely manner and that assessment should be on-going with lessons altered based on the students' progress. When Denise was asked about the types of assessment practices she had heard of, she provided an extensive list. She had attempted to use all of these, but had subsequently abandoned some. She provided the following examples of assessment techniques in this particular order.

- (1) Tests and Exams

(2) Quizzes

For Denise, quizzes are generally brief, yet frequent. They can vary from two or three fill-in-the-blank questions to up to ten of these questions plus one or two short response questions or investigations. In many cases, the questions parallel those recently completed for homework

(3) Group Assignments

Students would be placed in groups of two, three or four. They would be given the assigned questions and be asked to complete them in the allotted time. They would work collaboratively, and hand in or present the completed work to the class.

(4) Presentations

Although she had students present projects, most presentations are restricted to students demonstrating a solution to a simple one or two step question or giving a solution to a problem from their group.

(5) Projects

For the academic and advanced students, projects are restricted to chapter projects that are found within the prescribed textbook. These are not research projects, but rather a challenging problem, typically based in the real world, where students are expected to apply what they have learned in the chapter. In some cases Denise asks the students to provide a written solution and explanation for the project, however, she has asked on occasion for posters or class presentations. In the past, non-academic students would do projects that were of a more practical nature. For example, the project may involve developing a budget using information they had gathered from newspapers or the Internet.

(6) Assignments

Assignments, from Denise's perspective, are opportunities to revisit topics with which students are struggling. For example, setting up the constraints in linear programming is challenging for most students. Denise finds that assignments are a great means of offering additional support and practice throughout the topic rather than waiting until the end of unit test.

I don't plan my assignments at the first of the semester and say I'm going to have five assignments or ten assignments or whatever. I tend to give them an assignment to try to give them more practice and to see if they understand the concept we are working with.

(7) Homework Checks

Denise used to check homework on a daily basis and assign a mark at the end of the semester or term. With the Department of Education mandate regarding homework marks and authentic assessment, she has switched to homework quizzes, where students are required to hand in one randomly selected solution to a homework question or write a quiz relating to the assigned homework.

(8) Written Responses

Written responses may appear on tests, quizzes, assignments, or journals. These are opportunities for students to demonstrate understanding beyond the successful completion of an algorithm.

(9) Journals

Denise wasn't sure if the journals she asked her students to complete were truly journals. Students weren't asked to reflect upon what they had learned that day but rather address a specific question and explain how that question could be solved.

(10) Research Paper

Students were expected to research a mathematical topic of their choosing. Once the information had been collected from multiple sources, students would complete and submitted a formal research paper.

*Assessment practices that Denise has used.*

Denise supplied ten different assessment practices that she had heard of, all but one she has tried at some point in time. Although she has never used the research paper format, she had done some initial planning to use them several years ago. This planning coincided with the implementation of the Grade 11 mathematics courses. One unit in this course was devoted to an independent study. Denise saw this as an opportunity to have the students complete a research paper. She contacted one of the English teachers in her school and proposed that they work collaboratively on this research paper assignment. Students enrolled in both courses could do one paper and submit it for two subjects. Denise would mark the math content and the English teacher would be responsible for grammar, spelling, punctuation, and sentence structure. Unfortunately, for reasons that she didn't elaborate on, this collaborative effort never took place.

Journals were the one assessment tool that Denise has used but has since abandoned. Although she fundamentally agrees with the rationale for journals, she didn't find it provided her with any additional insight into the level of student understanding. She was generally disappointed with

their responses finding that they were "too vague" or that "they lacked the vocabulary" to adequately explain the concept. It caused her concern that responses from a group of friends were often very similar. Denise concluded that journals in her classroom weren't "a good assessment tool to really see what they (the students) were thinking." She also found them very time consuming from a teacher's perspective. Based on these factors, Denise decided to move away from journals in favor of other forms of assessment.

In terms of assessment practices that Denise is still using, she initially focused on tests. Her testing style has changed significantly over her career. She has attempted "to get more varied, thought-provoking questions, and not just regurgitation type questions." She wants them to "really apply what they know" and move away from questions that merely involve the manipulation of an algorithm. Denise has also incorporated questions from old provincial exams on her tests. She feels that it is important for her students to see a variety of questions but also the variety of alternate wordings for a question. Students must learn that one question can not only be asked one way. Denise is pleased with the format and quality of questions on her present tests, and uses what she has learned to also produce better quizzes and assignments.

As previously mentioned, Denise believes that quizzes should be brief and frequent. She uses them as an opportunity to see how students are progressing with a current concept. They are designed "to see if they (the students) have the idea" and "see how they are doing." This provides feedback to Denise on how to proceed with subsequent lessons. Should she revisit topics, consider remediation, or proceed with the next lesson? From Denise's perspective, quizzes are one of the most useful assessment tools when attempting to address these questions.

Group assignments are still a component of Denise's assessment practices but she does acknowledge that this form of assessment has been ineffective on some occasions in the past.

When she started using group assignments, she had the students work in groups of four. Invariably, there would be a few students scattered amongst various groups who would not engage in the assignment. It may have been due to a lack of understanding and/or a lack of interest. In some cases, these students became disturbance problems, undermining the value of the group assignment. When the group assignment was handed in, Denise was concerned that all members of the group received the same mark, even though an isolated few failed to truly participate. With time, Denise discovered that pairing appeared to be a far better form of grouping as it was fairer to the students and gave her more insight into level of student understanding.

I did group work, in groups of four, for a while, but found out that it didn't always work . . . A student who does their work all the time still did their work in a group. The student, who was causing a disturbance all the time and not doing his or her homework, would be the same person in the group who did not work. Assigning roles in the group did help them focus but there were still times when the students got off-task. I found it much better to have the students work in pairs where they had more responsibility to do the assignment. Actually, the weaker students worked much better if they were sitting with one other person because they would ask one other person for help but didn't want to show they didn't know something in a group of four.

Earlier it was mentioned that Denise had to change her homework checks to conform to the Department of Education's policy. She is troubled, however, that her alternate assessment technique does not serve the needs of students because it provides little incentive for them to attempt or complete the homework. She is conflicted and tries to give quizzes that does check on the understanding that the students have after doing the homework.

I use to do things like homework checks and because we were told that we're not allowed to give a homework mark, I moved away from that. I still believe that giving ten points for homework over the entire year is nothing compared to the benefit the students receive from it. The students are ready for the next class and homework can be dealt with quickly. Homework provides another learning tool.

Denise still uses presentations in both formats, project presentations and brief solution explanations. She didn't elaborate further, however, she indicated that she isn't using this form of assessment as frequently. She felt that the semestered system and the extensive number of outcomes that have to be addressed, made it far more difficult to justify precious class time for the preparation of presentations.

Denise uses written responses. Their frequency, however, is dictated more by issues of time, rather than her belief in this form of assessment. She sees the value in this form of assessment because it forces students to consider the rationale for learning a concept and/or a technique to solving a particular problem. Understanding is a fundamental component of Denise's conception of mathematics, and she endorses assessment practices that support this.

It is important to ask open-ended questions or questions that ask students to explain, for example, what is significant about a particular point on a graph under given conditions.

Denise identified that merely obtaining a correct solution did not convey understanding. Written responses encourage students to think beyond the rule.

### *Changes in Denise's assessment practices.*

Over her career, Denise has gradually transformed her assessment practices from tests and quizzes composed of rule-driven questions to a variety of assessment practices that give students greater opportunities to express what they know, share ideas, and ultimately learn. She learned that assessment was not merely a tool for measuring student performance but also to provide feedback so that lessons could be adapted, if needed, and concepts re-taught using different strategies. What factors influenced Denise's change in assessment practices? Denise cited several reasons for making changes in her assessment practices. Some had a positive influence while others affected her assessment practices negatively and were in conflict with her own conceptions of mathematics and teaching.

#### (1) Classroom Environment

With experience, Denise recognized that the background, ability, and confidence of students are major factors one must consider when selecting assessment techniques. If the technique provides little or no feedback to the teacher or student, and is not ultimately a learning experience for the student, then what purpose does it serve. As previously mentioned, journals, although pedagogically sound, seemed to provide little insight into student understanding when Denise attempted to use them. Presentations, another form of assessment, may work well with one group of individuals, however, for those that lack confidence, this form of assessment can be problematic.

#### (2) Graduate Courses and Curriculum Changes

Some may state that graduate courses and curriculum changes should be stated as two separate factors that influenced Denise's assessment practices. However, Denise would argue against that. The implementation of the new curriculum and her sabbatical leave coincided and both exposed her to a wide variety of alternate assessment practices. She

felt that these factors simultaneously made her reflect upon the practices she had been engaged in. The exposure to new ideas prompted her to try new assessment techniques.

### (3) Time

Denise is extremely troubled by the lack of time in a semestered system in relation to the number of outcomes that must be delivered to students who sometimes are misplaced.

Although she believes that teachers teach students first and curriculum second, she feels that she has abandoned this philosophy.

I feel I have to teach to the outcomes and get them finished. When the students are having problems, whether I'm assessing it or not, it almost doesn't make a difference because I have to go on anyway. This is the feeling I get and I know that many people say well there are many kids who shouldn't be in there. Well, I don't think we're there to leave these kids behind. There are kids that are misplaced, taking the wrong courses, but we're still there to teach them. . . .

You're not just leaving the students that shouldn't be there behind, you're leaving half the class behind.

Altering assessment practices, to fit the curriculum and time constraints, rather than the student needs, leave Denise very uneasy.

### (4) Class Sizes

Denise stated that large class sizes, particularly at the Grade 10 level, were making it difficult to assess properly. With so many students, many of whom were struggling with the material, it can be difficult to create a manageable number of varied assessment tasks that provide feedback and learning opportunities. Creating assessment items and marking

them has become a very time intensive activity and difficult to manage for even an experienced teacher.

*Summary.*

Denise is generally pleased with her own knowledge of alternate assessment practices, however, she is very concerned that this knowledge is difficult to use in our current system. She knows how she wants to assess her students but feels that the semestered system and a curriculum comprised of many outcomes, makes varied forms of assessment difficult, if not impossible, to implement. Denise's time is consumed with the delivery of the curriculum and providing extra help. Like her students, she feels overwhelmed by the amount of work that must be completed. The students just can't keep up and using different assessment techniques doesn't address the real problem; there is just too much in the course. The pressure to deliver all of the curriculum using the recommended timelines is in conflict with Denise's conceptions of mathematics and beliefs regarding good teaching practices.

Denise believes that when the new math courses were implemented a great deal of inservicing took place. This inservicing seemed to slow down as the Math 11 and Math 12 courses were introduced. Many teachers did not receive the inservicing that was available because of changing assignments or because they were new to a school.

Denise suggested that changes have to be made at the provincial level in order to insure that all students are taught using a timetable and curriculum that is conducive to learning, and that assessment practices be fair, varied, and rely on more professional judgement from the individual teacher.

### *Themes Emerging from the Interviews*

Each teacher had a unique story, however, three broad, yet common, themes emerged. The first theme addressed the unique and innovative alternate assessment practices used by the participants. The second theme focused on participant concern regarding the direct and indirect influence of Board and Departmental policies on assessment practices. The third theme centered on possible techniques for exposing teachers to a greater number of varied assessment techniques. Each of these are more fully elaborated upon in the following chapters.

## Chapter 5 Alternate Assessment Practices

### *Two Factors Influencing the Selection of Alternate Assessment Practices*

Research suggests that a teacher's conception of mathematics can be one of several factors that influences the teacher's selection and/or development of teaching and assessment items (Thompson, 1992). Three of the four participants indicated that there is a strong correlation between their conceptions of mathematics, their views on assessment practices, and the assessment practices in which they engage. For this reason, the first two sections of this chapter will examine each participant's conceptions of mathematics and views regarding assessment, prior to examining the alternate assessment practices they engage in.

### *Conceptions of mathematics.*

All but one of the participants, Denise, believes that their assessment practices aligned with their conception of mathematics. Andrea perceives mathematics as a series of interconnected topics tied together by understanding and fostered by problem solving and perseverance. Mathematics is a form of "mental gymnastics" where individuals have to be active participants. Craig's conception of mathematics can be summarized as a series of interconnected concepts, many with real world significance, bound together by logic in which one must understand how these concepts fit together. This understanding is only reached when one actively participates in mathematics and explores each of the concepts. Ryan's conception of mathematics is summarized as a series of interconnected topics bounded by understanding of the basic fundamental concepts of mathematics. There is also a level of practicality to mathematics as it has numerous applications to other disciplines. Since many mathematical problems require that one works with absolutes, this can provide a level of satisfaction for those wishing to master these basic concepts. Mathematics from Denise's perspective is about understanding concepts,

where these concepts come from, and why they are important both in mathematics and in other disciplines. Mathematics requires one to be flexible in their thinking as there are often multiple strategies that can be employed to solve a particular problem. She contends that problem solving is an important component.

Although these four participants came from different educational backgrounds and taught in different schools, their conceptions of mathematics were quite similar. If one considers the three categories for teacher conceptions of mathematics as defined by Ernest, one can conclude that the four participants identified some criteria from both the first and second categories.

(1) In the first category, teachers perceive mathematics as dynamic; a continually expanding field of creativity, imagination and invention. Problem solving is integral and students are required to understand patterns and use that understanding to create knowledge.

(2) In the second category, teachers perceive mathematics as a static but unified body of knowledge bound together by meaning and logic. All the truths are known.

(Ernest as cited in Thompson, 1992)

Ernest's third category, where teachers perceive mathematics as a collection of facts, skills and algorithms, did not apply to the four participants.

Using Ernest's first two categories as a template, the participants' collective conception of mathematics might best be described in the following way. Teachers perceive mathematics as a static but unified body of knowledge bound together by meaning and logic. Problem solving is integral and students are required to understand patterns and use that understanding to create knowledge.

*Assessment from the participants' perspectives.*

Prior to examining the alternate assessment practices used by the participants, it is important to understand what assessment means for each of the participants. In Chapter 2 of this thesis, eight components of assessment were identified. Each of the participants directly or indirectly identified most of these components.

Components of Assessment as Identified by Participants

	Andrea	Craig	Ryan	Denise
Allow the Students to Reach Educational Goals	√	√	√	–
Should be Continuous and Dynamic	√	√	√	√
Includes Formal and Informal assessment	√	–	√	√
Allow Teachers to Make Instructional Decisions	–	√	√	√
Used to Judge Student Ability	√	√	√	√
Should Celebrate Student Achievement; Provide Feedback	√	√	√	√
Include Authentic Assessment Tasks	√	√	√	√
Use a Variety of Assessment Techniques	√	√	√	√

The following table indicates what types of assessment practices the four participants presently use or have attempted to use. There may be some overlap between these different assessment items. Similarly, there is overlap between mathematical literacy and journals, but they should be regarded separately for this study. Some participants had literacy components on test, quizzes and/or assignments but did not use journals. This table is not supplied for statistical purposes, but rather as an organization tool for the reader of this thesis.

Assessment Practices the Participants Have Used or Attempted to Use

√ - presently uses this form of assessment

O - occasionally uses or has attempted to use this form of assessment

	Andrea	Craig	Ryan	Denise
Tests and Quizzes	√	√	√	√
Assignments	√	√	-	√
Portfolios	O	O	-	-
Journals	√	-	-	O
Independent Study Project	√	√	-	-
Presentations	O	-	-	O
Observational Checklists	O	-	-	-
Homework Checks/Probes	√	√	√	√
Exams that Include a Collaborative Component	-	O	-	-
Open-Ended Questions	-	-	√	-
Extension Questions	√	-	√	-
Cafeteria Testing	-	-	O	-
Mathematical Literacy	√	√	√	√
Reflective Self Assessment Prior to Test	-	-	√	-
Projects	O	-	-	√
Research Papers	-	-	-	O

The information in these two tables indicates that these participants are knowledgeable with a variety of assessment practices that aligned both with the NCTM Standards and APEF curriculum.

#### *Alternate or Unique Assessment Practices*

All four of the participants engaged in at least one assessment practice that would be considered alternative and/or unique. In this chapter four alternate assessment practices recommended by participants will be examined: (1) pair quizzes and assignments, (2) independent study units, (3) cafeteria testing, and (4) reflective self assessment prior to a test.

#### *Pairs quizzes.*

Both Andrea and Denise are proponents of pairs quizzes and assignments. Andrea typically marks only one of the two papers submitted by the pair. She feels that it forces the students to

debate various mathematical concepts until they can arrive at a strategy and solution that the partners are comfortable with. Unlike individual quizzes, Andrea believes that pairs quizzes are beneficial to the student who is struggling with a new concept.

A lot of times it was because, like I think I knew I didn't want to penalize students who were slower to be picking it up, and so, if I arranged an opportunity where they could work together, I had no problem with that, because I figured they were learning something. They were using the language, they were you know, stating, making a case, stating reasons, they were doing all of that stuff that we want them to do. But then I always felt compelled to give a mark. It was never enough just to give feedback.

Andrea's propensity to mark these activities may be a reflection of the students' motivations to complete such activities. She feels that students are less likely to engage in a quiz or assignment if they believe that it will not be marked. Research (Wilson, 1994) supports this finding; high school students are very cognizant about budgeting their time and energy and therefore are less likely to engage in activities that are not graded.

Denise voices concerns regarding group quizzes, believing that some group members are not active participants in the learning process. For this reason and for the concerns of her weaker students, Denise adopts pair quizzes and assignments. She feels that weaker students are less threatened when working with one partner, opposed to two or three. They are more likely to ask questions when paired with another student.

Actually the weaker students worked much better if they are sitting with one other person because they will ask one other person for help but they don't want to show that in a group of four. In fact, one of my students came to me the other day and asked if he could

move his seat because he would like to sit there, he named the other people, because he said I need help and I can have that help. And I thought that was really good, that he wanted to do that.

From Denise's perspective, the non-threatening nature of a pairs quiz or assignment, creates an environment where students anticipate some level of success. She believes that this anticipation of success serves to motivate students to engage in the assigned task. Research agrees with Denise's observation. "Students will engage in mathematics if they expect to be successful" (Middleton & Spanias, 1999, p.68). Denise is not advocating the use of ability grouping; the pairs are not selected based on similar mathematical ability. Such groupings create unequal learning groups within the same classroom and create a greater gap between low- and high-ability students. By contrast, mixed ability groupings, show significant gains for average- and lower-ability students, and negligible differences for higher-ability students (Linchevski & Kutscher, 1998).

Research states that assessment practices should be fair, acknowledge diversity amongst students (Lesh & Lamon, 1992), and foster self-esteem and self-confidence (Morgan, 2000). From Denise's and Andrea's perspective, this was achieved using pair quizzes and assignments.

#### *Independent study unit.*

Both Craig and Andrea advocate the use of an independent study unit. Andrea describes the development of her independent study unit in the following manner.

Ultimately, it was because there was no time to get through it, okay, that was the driving force. When, in Grade 12, we had a meeting, a couple of meetings in fact, the Halifax

leaders of all the high schools, math leaders of all the high schools in HRM, to try to figure out ways of addressing the grade, after the January exam, how do we do a better job? . . . And getting through the course was tricky, we all knew it would be, so it was a matter of, well what could we do an independent study on? And somebody suggested probability, and I didn't like that, because I think you need to talk a lot about probability. We ended up doing the coordinate geometry, just that one section I think is 4.2, we put it together as coordinate geometry, had maybe a lesson or two talking about geometric shapes, and showing the formulas, came up with a bunch of websites, took the problems from the textbook, but laid it out so that the diagrams were started for them, and nice and neat, and everything, and they had space to do their questions, and they worked on it, and I think they had something like four weeks or so to get this done. If they needed extra help, they could come in for help. We might have taken a class or two during the whole duration of the thing, just to address certain problems, like the ones with the more general proofs, and then they wrote a test, they handed it in, and wrote a test that day. If they had a mark on the test of over 75, it was, the independent study was valued at 10. Of that 10, five points was for the work they did, which was a fairly huge bundle, and five was the test mark. Okay, so, and I can't remember what the test was out of, but at any rate, if their score on that test was 75 percent or higher, this was an automatic five.

Andrea has carefully developed a unit that allows students to take ownership while still providing adequate support and incentives. Such careful planning allows Andrea to feel greater comfort when assigning this unit,. This is not a feeling shared by all teachers. "Giving students freedom to influence their own learning is frightening, creating in teachers a feeling of being out of control" (Tahta et al, 1994, p.27).

Craig uses his independent study unit to cover the topics of permutations, combinations, and probability. This unit was developed collaboratively with other teachers in his department and takes the students approximately four weeks to complete. There is a quiz at the two week mark and a test at the end of the four weeks. The students are also required to hand in the assigned questions from that unit. By incorporating a quiz, test and an assignment within the unit, Craig hopes that this would motivate students to engage in the material and ultimately achieve the educational goals, a view supported by research (Clarke, 1997, NCTM, 1989, 2000). The unit and the related evaluation techniques are designed such that students can enhance and expand upon their own knowledge of mathematics. The unit is not designed solely for the purpose of assigning a mark to a specific outcome or outcomes.

From Andrea and Craig perspectives, these independent study projects and related assessment items are valuable learning tools. They force students to understand patterns and use that understanding to create knowledge, a notion supported by research (Ernest as cited in Thompson, 1992). In such a setting, teachers are facilitators of learning and students are actively involved in exploring mathematics and formulating ideas (Thompson, 1992).

#### *Cafeteria testing.*

Ryan and his colleagues have used two assessment techniques that may be considered both unique and innovative: cafeteria testing and reflective self-assessment prior to a test.

With cafeteria testing, students are given a 50 point test where 30 points are derived from a series of questions of varying levels of difficulty and point values. More precisely, there are three questions, each with a part (a), (b), and (c), worth 6, 8, and 10 points respectively. The 6 point questions are more procedural in nature while the 10 point questions are problem solving

questions. "Students could choose which level they wanted to answer and if time permitted they could answer the 8 and attempt the 10 or do the 6 and attempt the 10 to get the best (mark possible)." This is probably best illustrated by the example Ryan provided. For the 6 point question the student may be given four ordered pairs and asked to prove that the quadrilateral formed from these four vertices (ordered pairs) would be a rectangle. The ordered pairs would be comprised of numerical values for the 6 point question. For the 8 point question, the same question would be asked however, one or two of the ordered pairs would include variables. For the 10 point question, all of the ordered pairs would include variables. Although the same principles were being used to solve these three questions, the level of sophistication was far less for the 6 point, versus the 10 point question. This form of assessment allows for different levels of sophistication when dealing with student responses as prescribed by the NCTM (1989). It attempts to provide a selection of questions that are "appropriate for the ability, age, and grade level of the student" as recommended by CRAME (1993, p.2). It can also be classified as a fair assessment practice because the students are supplied with point values so that they can understand which responses will be considered outstanding opposed to those that are considered average (NCTM, 2000).

*Reflective self-assessment prior to a test.*

Reflective self-assessment prior to a test is an innovative technique Ryan's students used to prepare for an upcoming test. In this case, students are not only asked to develop their own review materials but also justify their selections. This is accomplished in a four step process that ultimately encourages students to take greater responsibility for their learning, forces them to reflect upon the concepts learned, and requires that they provide written explanations for each of their review questions.

I would develop a review for them for the first test and tell them...give them a week to do the questions ...I would say to them here's the review that I want you to have ready for next week's test. I want you to pass it in the day before the test. It's worth 5 full marks of the term. It's on questions that we had done in class and therefore should have the answers for. Then I would discuss with them how I made up the review, the fact that it had a sample of this type of questions, this type of question, this type of question. Then second review I always said to the students, OK let's open a book and you tell me which questions we need to review. Put them on the board and then we would decide as a group which ones to strike off and that would be their next review. The third one I would get everyone to pass in what they thought the review questions should be and then I would sit down and pick them out and say these are the questions they chose.

From Ryan's perspective, the process of discussing the student's selection of questions is integral. It is an opportunity to see if the students have identified and understood the major concepts in that section of material. It allows the students to compare their own expectations for the unit with those of their peers and teacher. This approach is consistent with research which states that assessment activities should be "designed to make students reflect, think and make their thinking public" (Lee, 2001, p.43). Another significant feature in this third stage of Ryan's assessment technique is the employment of self-assessment. The students are not asked to pass in their questions, but rather, determine through class discussions if their questions address all the concepts and outcomes of the specified section, and are likely representative of the questions that will appear on the upcoming test. Self-assessment has a positive effect on student learning (Lee, 2001, Stallings & Tascione, 1996, Swan, 1993, Wilson & Kenny as cited in NCTM, 2000).

We have employed student self-assessment and self-evaluation in our high school and college mathematics classes and have found that the processes engage students in

evaluating their progress, aid in developing their communication skills, and increase their mathematical vocabulary. Most important, students reflect on their understanding of mathematics and on their ability to learn mathematics. (Stallings and Tascione, 1996, p.548)

Ryan described the fourth step in this form of assessment in the following manner.

And the fourth one they would just do their own review and pass it in....If there was more time I would like the students to write about how they do a problem, not just do the example, ... write down each of the steps and why they did the steps . . . write down little things to jog their memory.

At this stage, he is incorporating a literacy component into this form of assessment. This requires that students go beyond the manipulation of symbols and numbers, and provide a rationale for using a specific strategy. It also encourages students to use the appropriate mathematical language. In many ways, Ryan's fourth step in this assessment practice is very similar to the use of journals and portfolios. One might expect that it would have similar benefits. The student's resulting review materials with explanations have the potential to show evidence of ongoing mathematical learning, relate to the outcomes in the prescribed curriculum, and force students to take ownership of the materials. Implementing such an assessment technique to obtain these benefits is supported by research (Marlow, 2000).

Ryan's assessment tool was designed so that students could identify the underlying concepts and their interconnections. This was done in an attempt to improve student learning, and not merely to improve test results. This formative approach to assessment is supported by Lee (2001).

Over time we saw these teachers change the way they thought about and planned their lessons, incorporating different tactics into their repertoire in order to enable formative assessment to happen in their lessons. They began to think about ways to assess the pupil's understanding of a topic, to enable the pupils to articulate what they know and thereby allow the teacher to move their learning forward. (p.40)

### *Summary*

The four participants identified four alternate assessment practices, that from their perspectives, allowed them to deliver and assess the APEF curriculum, largely maintain their concepts of mathematics, foster student independence and ownership, and improve student learning. These alternate assessment techniques included (1) pairs quizzes and assignments, (2) independent study units, (3) cafeteria testing, and (4) reflective self-assessment prior to a test. The common thread through all of these techniques was that they were less threatening than traditional forms of assessment and that they also served as valuable learning experiences for students during the completion of each. This is significantly different from more traditional assessment practices such as tests or quizzes, which from the students' perspectives are more stressful events and tend to merely assign marks to what a student knows and doesn't know. The opportunity to improve student understanding doesn't occur during a test or quiz, rather after it.

## Chapter 6

### Effects of Departmental and Board Policies on Assessment Practices

All four participants stated that they had altered their assessment practices based on Department and Board policies directly or indirectly tied to the issue of assessment. Some policies created time restrictions that affected the delivery and assessment of curriculum. Other policies focused on the types of assessment that the province deemed authentic, forcing the participants to re-examine the assessment of homework and deviations from the prescribed curriculum.

#### *Lack of Time to Deliver and Assess Curriculum*

Policies, that directly or indirectly limited the time to deliver and assess curriculum, had affected each of the participant's assessment practices. Each participant identified practices that had been altered in an attempt to address this lack of time. These altered practices included the reduction of the problem-solving assessment, introduction of the independent study projects, elimination of the collaborative components on final exams, postponement of cafeteria testing and the almost complete elimination of classroom presentations. The participants identified five common sources that had contributed to their perceived lack of time to deliver and assess curriculum. These sources were (1) the requirement to use discovery learning, (2) the implementation of semestering, (3) policies on absenteeism, (4) introduction of out-come laden curriculum, and (5) the reduced timetable for the scheduling of exams. All of these matters arise from policies created by the Department of Education or regional school boards.

#### *The requirement to use discovery learning.*

Three participants felt that discovery learning required additional time and could contribute to the perceived lack of time to deliver and assess curriculum. Andrea stated, "Students need to think about their learning, need to refine their thinking, need the experience to do that, and that

takes time." Ryan concluded that "discovery learning can be apt for some situations but can lead to unwise use of learning and informal assessment time." He added that one needs "guided investigations in order to use classroom time wisely." Denise, like Ryan, felt that the investigations should be more guided so that teachers and students could complete them within the allotted time and yet allow students experience discovery learning. She stated, "Now I tend to lead them through these investigations because I just don't think there is enough information in some of the investigations and I don't have time in the semestered system."

Cathy Seeley, a past NCTM president, acknowledges that reform approaches do appear to take more time, but she asks that teachers consider the benefits of such approaches to long-term student understanding.

You have identified the factor that is the most universal barrier cited by teachers in improving their teaching the way they might like—having enough time. It isn't so much about managing the time as about viewing it differently and rethinking curriculum. I would view many excellent practices and effective strategies not as an expenditure, but rather as an investment. When we teach for lasting understanding, it takes longer. But when students learn something and understand it at a deep level, they are much more likely to remember it and not to require the relentless annual reteaching that has become part of our culture. (2005, p.6)

The Nova Scotia Department of Education also recognizes that discovery learning, although beneficial to students, does require time. Even though the number of mathematical concepts that are delivered to secondary students hasn't changed greatly over the last twenty years, the introduction of discover learning does mean that additional time is required to address the same concepts (Karsten, personal communication, June 4, 2006).

The participants' views on discovery learning should be examined when one considers their observations regarding the additional classroom time required to incorporate discovery learning. Two of the participants are strong proponents of discovery learning, while the other two acknowledge its benefits but use it less frequently or in modified forms. Andrea and Craig supported the Department of Education's initiative to make discovery learning a major component of the secondary math programs. Craig gave the strongest endorsement of discovery learning when he stated the following.

I think one of the things that I now appreciate, is that students learn best when they do it for themselves. I think that if you were to look at a classroom that I'm in today, you'd probably see the true, so-called constructivist classroom, where the kids are allowed to explore concepts of their own, they form opinions, we share ideas, and I try very hard to be not much more than a mentor, where at some point during the lesson, I try to help the kids bring all the ideas together, and bring the lesson to a closure where we all walk away with a similar sense of meaning to the topic.

Ryan was pleased that the new approach encouraged student understanding however, did not feel the discovery approach should be used in almost every lesson. He felt that there were times when more traditional lessons could and should be used. He stated the following.

I believe that your lessons can be varied so that you are teaching directly to single people, pairs of people and groups of people. . . Discovery has its place but only for certain students, just as rote learning has its place for only certain students. I think the class has to have a combination of rote, exploration and summarization where the summarization comes from the teacher or the students.

He felt discovery learning had its place in today's classroom but that did not mean we should abandon all traditional practices. " I don't think you need to throw the baby out with the bath water." This is an interesting comment in light of a recent interview with Cathy Seeley. She stated the following.

Whether a teacher employs a discovery approach to learning or direct teaching or any other approach isn't as important to student learning as the learning tasks students engage in. Looking at classrooms in the united States and in other countries, Hiebert and Stigler have found, through a careful analysis of the TIMSS data, that the most important thing with respect to student learning is the nature of the learning task students engage in. Students need to be mentally engaged in challenging and worthwhile mathematical task that emphasizes the conceptual aspects of the mathematical topic and promotes the formation of mathematical connections if they are to learn skills with meaning and be able to use those skills to solve problems. . . This can be effectively done in a range of instructional settings from the most student-centered to the most teacher-centered. (2005, p.4)

Her statement appears to diverge to some degree from prior NCTM teachings, which appeared to advocate extensive use of discovery learning. Her recent comments regarding the reformed approach to teaching and assessing of mathematics appear to closely align with those of Ryan.

Denise uses discovery learning. She feels that many of her students lack the skills and/or initiative to complete the investigations on their own. Regardless of the participant's feelings towards discovery learning, two agreed that this form of learning required additional classroom and preparation time.

*The implementation of semestering.*

All of the participants who worked in a semestered system felt that this scheduling option was partially responsible for their frustrations regarding the perceived lack of time. Denise was very troubled that many of her students were having difficulties grasping the concepts when she tried to adhere to the timeline and scheduling option suggested by the Department of Education. She felt obligated to finish all the outcomes in spite of the level of her students and her own perceptions of the teaching of mathematics. Too often she felt that she was moving on to the next lesson when many of her students were still struggling with the previous concept. "You're not just leaving the students that shouldn't be there behind, you're leaving half the class behind." Craig had similar concerns, stating that his teaching and assessment practices had become more "linear" due to the shortage of time in this setting.

Proponents of semestering contend that longer classroom periods are beneficial to investigative learning since students are provided additional time within one class to share, reflect, evaluate and restructure new concepts that were introduced. They also state that these longer periods allow teachers more time to implement a greater variety of learning and assessment techniques. (Carroll as cited in Runnels, 2006, Lyngard, 2004, Queen as cited in Cooper 2001, NSDE, 2002). The participants in this study believed that the benefits, associated with the additional 20 minutes, were negated by only seeing their students for half the year. They felt that overall they had less class time to deliver and assess the curriculum in a semestered versus non-semestered system. Research supports their impressions: although each period has increased in length, the total number of hours in a semestered versus a non-semestered course is reduced (Runnels, 2006, Cooper, 2001). As a result, less material is being covered. (Cooper, 2001, Wyatt as cited in Runnels, 2006).

Denise raised concerns regarding double periods that in a prior semestering schedule were occurring once every four days. She felt that these frequently occurring two hour periods were not serving the students' educational needs. In an attempt to alleviate this problem, her school introduced a timetable where a double period only occurred once every eight days. She contended that this change was beneficial to students.

With the double, where we have a double every four days, I feel that I have to give a quiz or something on that double because I can't keep them entertained for two full hours. But that way at least you're only having this real double every... once every eight days. And the other, as you say, you can view it as two separate classes.

Denise believed that frequent double periods could be detrimental to temporally sensitive students, those who suffer from attention span issues or other learning disabilities. Her observation is supported by research (Lyngard, 2004, Runnels, 2006).

Denise also raised a concern regarding semestering that was not experienced by other teachers. She was in the unique situation of teaching four courses in four periods for both semesters. This meant that she did not have a planning period in either of the terms. With no planning period, Denise found semestering not only demanding for her students, but also for herself. By contrast, Andrea and Craig, who had greater experience with semestering, were in their own unique situation since they worked for the Halifax Regional School Board. In this board, secondary teachers are responsible for three courses in a four period day in both semesters. This means that they have a planning period in both terms. The typical secondary teacher in the Province of Nova Scotia has one planning period in one of the two semesters. Research shows that having a planning period may contribute to a favorable response to semestering (Cooper, 2001) "It may be because students are receiving a better education, or perhaps it is because teachers only have

to prepare three classes a day with an 85 minute planning period, instead of five classes a day with a 55 minute planning period." (p.3).

*Policies on absenteeism.*

Teachers identified two policies relating to absenteeism, which they felt, in some way, impinged on their ability to assess students fairly. From Denise's perspective, the school-based policy of repeatedly excusing students absences for extra-curricular events was affecting her assessment practices, particularly as students approached the end of the school year. From Andrea's perspective, the Halifax Regional School Board (HRSB) policy of canceling bussing during inclement weather was impacting on her teaching and assessment practices.

Denise was concerned that several extra-curricular events coincided with the last few weeks of classes prior to the provincial exam.

I would say four major interruptions between now and the end of the year. We are talking about a large group of students who will be gone out of class maybe one class or maybe the whole day. As well as the sports that are at the end of the year here: softball, track. They involve all day for regionals and for provincials. As well...several students take off at 11:30 for softball teams ...like...so I would say that there is a major, you know, major loss of time. And then we have the grade twelves they've been involved in the fashion show that's coming up and you know they ...the fashion show, most of them will not be in class. So, these are kids who have to write the provincial exams.

Denise felt that the school should take a greater leadership role in assuring that extra-curricular activities didn't conflict with daily teaching, particularly in the last few weeks of any course. The Department of Education agrees with this and has been working with boards to address the

issue of instructional time lost due non-curricular activities. (NSDE, 2002) The Department is continuing to monitor schools in this regard and is presently drafting new documents that address this issue of absenteeism in greater detail. (Karsten, personal communication, June 4, 2006)

Andrea had similar concerns regarding absenteeism but she focussed on the HRSB's policy of canceling school busses on storm days, as opposed to option of canceling school.

Before, if the busses were cancelled, it wouldn't impact on our day, because all of our students were neighborhood students, right, but last year, because we had busses coming from out Sir John A way, and we had busses coming, you know, just in general, I probably had three or four different bus loads of kids, and so that would have affected things, because the kids who could walk were expected to be there, but you knew the bus kids weren't going to be.

Attendance at Andrea's school on these days was sporadic, making it difficult to proceed onto new topics. Unable to proceed to the next lesson only contributed to the feelings of frustration regarding the issue of lack of time.

Andrea and Denise stated that absenteeism was a factor contributing to their lack of instructional and assessment time however, they did not identify what assessment practices were directly affected by this problem. Both believed that this problem was compounded in a semestered versus non-semestered system. When students are absent in a non-semestered system, they are missing material that was covered in a 40 minute class. In a semestered system, however, a greater amount of material is covered in one period because the periods are 60 minutes in length. This problem escalates if the student misses more than one day and/or a double period. The

observation that student absence is more detrimental in a semestered versus non-semestered system is supported by research (Lyngard, 2004, Ross as cited in Runnels, 2006).

*Introduction of outcome-laden curriculum.*

From the participants' perspectives, curriculum that they describe as outcome-laden also contributed to the lack of time for the delivery and assessment of curriculum. They had abandoned some assessment practices and implemented others in an attempt to deal with the number of outcomes found in the new curriculum. Andrea and Craig felt that the independent study project was one assessment technique that could be used to insure that students completed the required curriculum in the allotted time. As mentioned in Chapter 5, to compensate for the lack of time in class, Andrea and Craig, in conjunction with their schools' mathematics departments, developed and implemented independent study units for student to complete outside of class. They decided what concepts could be covered in the project and how that work would be assessed.

All four participants felt that they were so busy delivering the curriculum that they did not have the opportunities to introduce alternate assessment practices that they valued. For example, in the past Andrea had devoted a significant amount of time to problem-solving. She stated, "You could find wonderful problems to get my kids going on, contest problems or whatever. That was great. I found time to do it then, but now I don't feel that I have the time." Denise had used presentations as a form of assessment but has since abandoned them. "Presentations; just presenting like small...small questions in class. I used to do more of that but not so much anymore. (Just out of curiosity, why is that?) Time, always comes down to time." Ryan had similarly omitted cafeteria testing from his assessment practices. "We moved away from it (cafeteria testing) because of the government's move towards the new textbooks ...ah...and the concept of exploration. We just didn't have enough time to do it. Next year the plan is to move

back to that." Craig stated that the extensive number of outcomes provide little opportunities for teachers to use their professional judgement to implement extension activities and alternate assessment practices.

*Reduced timetable for the scheduling of exams.*

Craig disagreed with the Department's directive to limit the number of days for final exams to eight for the whole year. For a semestered school that meant there were only four days allotted for exams each semester. This time restriction forced Craig had to forgo the use of his collaborative component on his final exam.

So typically what I would do, is I would give them a personal part of their assessment, which was somewhere between 75 and 80 percent, which would last about two and a half hours, in the morning. I'd give them an hour break, and have them come back that hour later in the afternoon, and then we would do a cooperative assessment item, where they would be put in groups of three on a random basis, they were presented with three problems they had never seen before, and they had to use their cooperative learning skills plus their mathematics as a group, to finish the remaining 25 percent of the examination period. I can't do that anymore because there's no room left in the structure with the examination to do that. So that's why I say, I'm not happy where I am with assessment now.

From Craig's perspective, this Departmental policy created time constraints that affected his assessment practices. Abandoning this collaborative component to the exam troubled Craig as it limited his ability to exercise professional judgement when it came to this form of assessment. The Department of Education states that the decision to regulate examination periods was done

primarily to reduce the loss of instructional time (NSDE, 2002), another concern previously identified by the participants.

### *Authentic Assessment*

Authentic assessment incorporates reasoning, multi-step problem-solving, a variety of possible strategies, and the use of technology (De Lange, 1993, Shannon & Zawojewski, 1995, Senk & Beckmann, 1997, Van Den Heuvel-Panhuizen & Becker, 2003). The wide variety of assessment practices and the variation in the levels of their assessment questions demonstrated that all four of these participants used authentic assessment, as defined above, on a regular basis. The Department of Education expanded upon this definition. To be deemed authentic assessment, the assessment must also be directly linked to a curriculum outcome. This was the contentious issue for all of the participants. Using this definition, it meant, for example, that marking homework to determine if it was completed was now considered as a non-authentic form of assessment. From the participant's perspective, it also meant that mathematical concepts that were no longer directly tied to an outcome could not be taught. In effect, the Department's assessment policies, defined using the term authentic assessment, could be used to insure that teachers worked only with the prescribed curriculum.

All four participants stated that homework was an integral component of the teaching and assessment practices. Craig stated the following regarding the issue of homework.

You can't evaluate homework as part of assessment, unless you mark it, right? You know, which makes it difficult for me because the kids tell me that one of the best motivators they have in mathematics, is to know that I am personally looking over their shoulder, and going to check their homework on an ongoing basis all the time. So, what I

have done, is I've beaten around the system, I might check one or two questions for homework.

Ryan raised similar points when he stated the following.

I think of authentic assessment verses non-authentic, for instance, homework is considered non authentic by some. (Is that your opinion?) No, I think that even if the kids have to go to another source they are learning something by looking at other peoples answers. I believe that for the amount it is valued at which is 7 points a term, if they want to go out and ... if they have a tutor that checks over all, that's for them to worry about. It's only 7 points a term . . I may say to them I'm going to check homework today, all I'm checking for is the fact that you've done or attempted the questions so I can get an idea of what I need to teach. And I give value for even attempting the questions.

The National Council for Curriculum and Assessment defines homework in the following manner.

Homework should be meaningful for the teacher and the student. It should serve to re-enforce work done in class and that it should act as a bridge between the work of one day and the next. It should be organically and systematically linked with and integrated into a programme of teaching and learning thereby forming part of the process of assessment for learning. It should be designed in such a way as to offer the students opportunities for self-assessment. . . . Homework helps students to construct knowledge, develop deeper understandings and connections amongst the concepts to which they have been introduced, and provides an opportunity for them to apply the skills they have acquired. (NCCA, 2006)

Although the Department of Education supports the use and assessment of homework, it does not support assessment that merely identifies whether homework is complete or not. The Department contends that such an assessment practice doesn't insure that learning is occurring and hence whether an outcome is being met. If teachers wish to include homework as a component of the final mark, they must assess specific questions that were assigned. (Karsten, personal communication, June 4, 2006) None of the participants were pleased with this decision but all had managed with varying degrees of success to work within these constraints.

From the participants' perspectives, not only did homework serve as a motivational tool but it also was a form of self-assessment to the student and informal assessment for the teacher. Research does support this but includes some cautionary notes. "When students are given incentives to achieve, the motivation and achievement of the entire class can be raised." (Alschuler as cited in Middleton & Spanias, 1999, p. 68) Other research states that intrinsic interest in the material is not effected by the presence, or lack of presence, of a reward. With a perceived reward, students will often engage in the activity however, the students may feel that it "is merely a means to an end." (Lepper & Greene as cited in Middleton & Spanias, 1999, p.68). The assessment of homework may motivate the students to complete the work but not necessarily learn the material. Other research contends that educators must be cognizant of the type and amount of homework one assigns. (NCES, 2000, TIMSS, 1999) Although students who completed their homework performed better in mathematics compared to their peers that did no homework, there was no statistically difference in performance of students spending any time between 15 minutes and one hour or more on homework. Some contend that the lack of statistical difference may be a reflection of the type of homework supplied and the care that a student takes when completing it. (NCES, 1991) For example, TIMSS (1999) asked eighth

grade math teachers how often they assigned homework based on investigations. Approximately 82% of the teachers had never or rarely assigned these types of questions.

Authentic assessment, based on the Department's interpretation, must be directly tied to an outcome for that particular course. Craig no longer feels that he can deviate from the curriculum to teach a valuable unit on income tax. He feels that this assessment policy, that was initially designed to effect his assessment practices, was also a means controlling what material he taught.

I think a number of schools as well, one of the major topics that I used to teach in the 11 academic program was the successful completion of an income tax form. I thought there was a lot of mathematics there. Probably took me the better part of two and a half weeks to do the course inside of the math course. I still meet kids 15 or 20 years later who tell me that it's the most valuable thing that they ever learned inside of a classroom. I think that's one example of me branching out in terms of, what I taught in mathematics in terms of what I felt was important. And by the way, looking back, I don't think I was that far off the mark, because if you think about filling out an income tax form, there's a lot more than mathematics there. There's mathematics and literacy skills, and one of the biggest problems that kids have always had is reading a set of directions, to fill out an income tax form, you have to read the booklet.

Craig's interpretation of the NSDE policy, restricts his ability to introduce and assess topics that he deems pertinent and relevant.

Similarly, Craig disagreed with the HRSB's decision to create a specific assessment plan that must be adopted by all teachers in the board. His own board was attempting to create their own definition for authentic assessment, more specific than the one proposed by the Department.

"Assessment and evaluation in the Halifax Regional School Board where I work, has got a very formal structure to it. The policy that we follow, is very similar across the board, whether it be a language arts or a math and science curriculum." Even though Craig was a member of the Assessment Committee, he felt that ultimately his objections to such a structured format for assessment were ignored. He was unhappy that such a policy would not allow him to exercise the professional judgement that he had used in the past. He begrudgingly has followed this new policy but questions the wisdom of such actions. Although Craig has not abandoned reformed assessment practices, he does feel that he has had to limit their usage based on edicts from an educational authority. Craig is not alone. Morgan (2000) states that teachers adopt reformed assessment practices if they perceive that such changes align with expectations of external groups.

### *Summary*

Although these experienced teachers were generally pleased with their teaching and assessment practices, they did feel that certain favored assessment practices were discarded in an attempt to navigate within a restrictive educational environment defined by Department and board policies. Some participants had abandoned presentations, collaborative components to exams, cafeteria testing, and assessment of relevant mathematics not found in the prescribed curriculum. In some cases, they had reduced their assessment of problem-solving skills, and all the participants had modified their assessment of homework. The participants contend the policy changes were directly or indirectly responsible for these changes in their assessment practices. Policies that restricted instructional and assessment time, and narrowed the definition of authentic assessment were cited as two areas of concern. The participants identified several factors that had contributed to the lack of time for delivery and assessment of curriculum. These included (1) the requirement to use discovery learning, (2) the implementation of semestering, (3) policies on

absenteeism, (4) introduction of out-come laden curriculum, and (5) the reduced timetable for the scheduling of exams. Andrea best described the dilemma associated with time when she stated the following.

Research tells us that in order for students to achieve course outcomes they need frequent, specific feedback about where they are in their learning, where they need to be and how to close the gap. Teachers on the other hand, are caught up trying to make sure that we have sufficient evidence (i.e. marks) to justify a grade. It takes time to both support learning and to measure it. Given the large number of outcomes and a semester system that limits opportunities for reflection and the adjustments that students make as they improve their understanding and skills, assessment for learning suffers.

The participants also felt that the Department's definition for authentic assessment had also affected their assessment practices, specifically in the areas of (1) homework assessment and (2) assessment of relevant mathematics not found in the prescribed curriculum. All of these policies, from the participants' perspectives, had an adverse affect on their assessment practices and in some cases, silenced their professional judgement.

In spite of this criticism of these Departmental policies, none of the participants expressed concern with the actions of present or past mathematics consultants for the Province of Nova Scotia, nor did they have any concerns regarding the Department's decision to implement external provincial testing at the Grade 12 level. All four had briefly mentioned the external exam but were not troubled by the process or the exam itself. One participant, Ryan, was pleased with the external exam; he viewed it as an opportunity to raise the level of mathematical understanding within our students. " I like the idea of a provincial exam. I think it forces everybody to try to reach a certain level." Ultimately the participants were not displeased with

all of the initiatives from the Department of Education, just those that were restrictive in terms of the delivery and assessment of curriculum within their particular setting.

## Chapter 7

### Exposing Teachers to a Greater Number of Assessment Techniques

The third theme that emerged from the interviews was the need to introduce teachers to a greater variety of assessment techniques and ways in which that might occur. All four participants made the same two recommendations for improvements in this area. They suggested increasing teacher support through the introduction of long term sustained professional development (PD) in both teaching and assessment practices, and creating greater dialogue amongst teachers regarding assessment practices.

#### *Teacher Support and Professional Development*

Based on the responses to the interview questions, it was apparent that the participants believed that teaching and assessment practices were fundamentally interwoven. When answering questions about teaching practices, the participants often mentioned assessment practices, and vice versa. In particular, when participants offered recommendations for improving assessment practices by increasing teacher support through long-term sustained professional development, they often suggested that the Department and boards to address both teaching and assessment issues.

All four participants, in varying degrees, felt that more assistance was needed from the Department and boards. Their emphasis was on greater opportunities for teachers to examine and experience alternate assessment practices, rather than on the area of development of assessment policies.

Andrea's initial concerns focussed on the perceived lack of support that existed around the discovery approach to learning.

And in terms of practice, like the investigative approach, I think we needed a lot more support with how to make that work. Because I think even people who started out positive about that, have done an about face, and are back to less investigation . . .

Andrea's feelings were confirmed when Denise disclosed that she initially attempted to incorporate true discovery learning in her lessons, however, she has "generally moved away from that" and now tends "to lead them (the students) through these investigations."

Andrea further addresses the issue of support as it pertains to assessment.

And assessment's something, that's another area I think we have been left totally in the dark about, totally. You know, here's a new program, have fun teaching it, figure out how to assess it, you know, you should be doing portfolios, you should be doing this, see you in five years. . . It was a very uncomfortable feeling, like you know, trying to figure out what the change should be, and then how you go about recording all this information. I found it very frustrating,

Craig recommends that if the Department or Board expects that a specific type of assessment practice is to be incorporated into all classrooms, they must provide some mechanism by which teachers who lack the training and/or experience in this area, can obtain it. He said, "I think that any form of assessment that we do, if a teacher is uncomfortable with that, then they always need some kind of support from either the school board, or the Department of Education."

Craig also stated that the Department had a history of supplying minimal support for teachers.

I've always been disappointed with the level of support the teachers receive from both the department of education, and from their school board. I think, to be perfectly honest with you, a lot of lip service is paid to teacher support, but a one day in-service always seems to fix the problem, and then off we go. So, I think most teachers are on their own when it comes to anything,

This does not mean that all the participants were totally dissatisfied with the efforts of the Department and school boards. Andrea and Denise acknowledge that attempts were made to support teachers in the early developmental stages of the APEF curriculum, even though some of the attempts were not as comprehensive and long-termed as the participants wished. Andrea said the following.

I think some things were attempted, you know, I can remember when the cookie, the linear programming first came out, and we actually had everybody in Halifax in-serviced with that. It was quite a coup, but it happened, and that certainly set the scene for looking at different ways to assess, you know that it could be more activity based, and so on, but there wasn't enough – I'm not saying that there wasn't anything there, but there wasn't enough.

Denise recognized that the Department initially endeavored to provide professional development but felt that these efforts gradually declined with time.

They were gung ho and did all kinds of inservicing when that first program came out...the Grade 10 program came out... um... and then the Grade 11 they slacked off a little bit and

then the Grade 12, they really slacked off and until they came back with the provincial exam.

She was additionally concerned that some newer teachers may have received little or no inservicing as it pertains to discovery learning or alternate assessment strategies due to a gradual decline in professional development over the last few years. She stated that many of the teachers who were able to experience those early professional development opportunities have now retired.

The experience of these Nova Scotia teachers is echoed in the research. It states that little professional development time is allocated to showing teachers how to use new forms of assessment and balance new forms of assessment with older more traditional forms (Senk & Beckmann, 1997).

The participants agreed that additional support in the form of professional development is needed and made four recommendations in this area. They believed that these PD recommendations would increase teacher exposure to and usage of alternate assessment techniques.

*Professional development that encourages incremental changes.*

Andrea contended that professional development sessions should encourage gradual change by focussing on one or two assessment issues, rather than examining a wide variety of issues. She stated that changes should be "incremental changes based on what you're comfortable with at the time." She felt that altering too many teaching and/or assessment practices in a short period of time can be problematic. Teachers become "frustrated" as they attempt to understand how, when, and why these changes should be incorporated into their daily practices. Webb (1992) concurs that change in assessment practices is a gradual and demanding process. Indeed, one

researcher states that change typically only occurs in increments of about 10% each year (Leinwand as cited in Senk & Beckmann, 1997).

*Long-termed sustained professional development.*

Andrea and Craig stated that professional development should be long-termed and sustained. She felt that this model gave teachers opportunity to reflect upon what they have learned. She also said that these additional sessions could provide "reinforcement" for strategies and materials discussed in earlier sessions. This recommendation is supported by research. Lappan et al states that sustained professional development, which provides both intellectual and emotional support, should be supplied over at least a two year period (Lappan et al as cited in Cooney, 1994). It also suggests this type of PD allows teachers to see how such knowledge can influence their daily teaching practices (Clarke 1994, Cooney, 1994). By contrast, isolated after-school or one-day regional workshops are the least useful forms of professional development (Zigarmi et al as cited in Clarke, 1994). Although teachers can acquire considerable information in a single workshop, "the translation of this information into their classroom teaching requires a sustained inservice program." (Cooney, 1994, p.11)

*New models for delivery of professional development.*

Ryan was interested in observing and interacting during PD sessions with individuals who had been using the new teaching or assessment techniques. He stated:

I'd like to see some examples that are being used. I'd like to, in some cases, observe someone using the type of assessment if it's something very new. I'd like to know the reason for using it.

Ryan's recommendation is supported by research: teachers need role models who can offer support and direction (Herrington, Herrington & Glazer, 2002). Andrea and Craig state that these role models should be experienced classroom teachers who are truly an expert in a particular area. They do not believe that the presenters should be individuals who have been recently trained, as is the case with the "train-the-trainer" model for professional development. Andrea stated that this model " goes against everything we know about learning." As an individual who has been trained in such a manner to disseminate new materials to others, she feels that she can only pass on the main points, with little or no opportunity to use these recommendations in her own classroom. As she states, " I can't see how that can work." Craig is even more critical of this model.

The Department of Education has itself fooled into thinking that they can produce these so-called experts in every school board, and then they will go off and dissipate the information, it just doesn't work. . . You cannot make experts in one day, who will then go off and trade it with another 30 or 40 people.

*Increasing teacher accessibility to research findings.*

Andrea was the only participant to recommend that teachers examine the research associated with assessment. Such opportunities could expose teachers to a number of ideas connected directly or indirectly with assessment policy and practice.

There's incredible research on assessment for learning out now. I think quite convincing. I would need some exemplars, how does it work, what does it look like, how do I use the results, like it wouldn't have to be totally prescriptive, but at least give me something to start with,

This could identify the types of assessment practices that could be used, as well as, explain the rationale for these practices. Literature states that clarifying the rationale for such reforms is instrumental in the adoption of these reforms (Valdez, 2004). Andrea added that increasing teacher accessibility to research findings does not have to be limited to PD sessions. She wished teachers had enough time to independently explore recent educational research inside and outside of regular school hours. She felt, that in the current system, such explorations would be hampered by heavy workloads, inflexible timetables and curriculum that cannot accommodate lost instructional time or deviations from the prescribed curriculum. Research contends that this sort of independent work outside of structured PD days should be encouraged. By doing so, it provides teachers the opportunity to take greater ownership for their professional growth (Clarke, 1994).

Cathy Seeley, the past President of the NCTM, agrees with Andrea in that teachers do not have the opportunity to examine relevant research. Seeley, however, questions whether teachers are truly motivated to examine such research. She states that unfortunately "teachers don't have the time or interest to read lengthy reports that may not immediately usable." (2005, p.6). From her perspective, the role of the NCTM is to provide concise and readable research briefs that focus on linking research and practice.

In attempt to provide the Department of Education's perspective on professional development for secondary mathematics teacher, Donna Karsten, the provincial mathematics consultant, was contacted for a brief telephone interview on June 10, 2006. She addressed two issues during the interview. The first was the delivery model for professional development presently used and the second was the perceived lack of support regarding PD, specifically in the area of assessment. She states that the Department of Education recognizes that there is a need to change the present

model for professional development. The "train the trainer" model has been abandoned in the primary to Grade 9 levels in favour of a model that incorporates mathematics leaders in every board. These leaders, hired in full time positions, are responsible for identifying the needs within schools and the board such that resources and inservicing can be provided. At this point in time, a similar model has not been applied to professional development at the Grade 10 to 12 levels. Preliminary planning, however, has begun on the development of Professional Learning Communities (P.L.C.) and Network Learning Communities (N.L.C.). These learning communities are designed such that teachers within schools and boards, can meet, discuss, and work collaboratively to find resources and inservicing opportunities that address their unique needs. From the Department's perspective, the major concern associated with these learning communities is the issue of time: the Department is uncertain how it is going to be able to bring so many teachers together for such events without sacrificing valuable instructional time.

Ms Karsten also recognizes that during the implementation of the APEF secondary curriculum, limited time and resources were allocated to the issue of assessment, however, steps have been taken to try to rectify this problem. Prior to the introduction of the Grade 12 provincial exam, the Evaluation Division of the Department of Education conducted numerous workshops on the types of assessment items that should be used in the classroom and would appear on the provincial exam. The Department also created the Mathematics: Item Bank for all seven core mathematics courses at the secondary level. This online question bank is comprised of assessment items grouped according to course, outcome, and assessment level. This item bank was designed to support teachers as they attempt to address the issue of assessment within the APEF curriculum. Both of these initiatives were adopted in an attempt to provide greater support to teachers in the area of assessment.

### *Teacher Dialogue*

All four participants stated that teacher dialogue within and outside of their school was instrumental in improving their teaching and assessment practices over their careers. They contended that individual teachers and mathematics departments within schools should actively pursue opportunities that encourage greater teacher communication. They felt that if teachers had opportunities to exchange ideas regarding assessment, these teachers, at the very least, would be exposed to a greater number of assessment techniques. Between them the participants made four recommendations for increasing teacher dialogue. Not all of these suggestions were made when the participants were discussing the issue of assessment. In some cases, the suggestions arose when the participants were elaborating upon their own professional development or factors that effected their teaching practices.

### *Increasing dialogue within schools.*

Three of the participants stressed that working in a collegial school environment in which teachers could share ideas and materials was beneficial to both their teaching and assessment practices. Having the opportunity to communicate with experienced and motivated teachers, often under the supervision of a knowledgeable mathematics department head, was an important issue for these three teachers.

Craig stated that he looked, somewhat unconsciously, for schools that possessed collegial environments that supported teacher dialogue.

I've always worked in an environment where teachers work very collaboratively together. And I've always been lucky in terms that I've felt that I've worked in progressive schools, but maybe it's not luck as much as one looks at progressive schools, and then tries to transfer into them. . . I've also been very lucky, in most cases, I've worked with

what I would consider to be a highly motivated group of mathematics teachers. . . I've also kind of surrounded myself with highly motivated mathematics teachers. I tend to quickly dismiss and move away from the negative group.

Working for four different schools within the Halifax board was important to Andrea as she tried to develop teaching and assessment practices that aligned with both the curriculum and her own conceptions of mathematics. Working and communicating with a diverse group of teachers provided " a lot of opportunity to see a lot of different things" and resulted in "a lot of sharing." Although she has learned much from her colleagues, Andrea saved her greatest compliments for a department head whose guidance was exceptionally important in the early part of her career.

When I started teaching at (name of school), my department head was not a great communicator, so it, we had our challenges, but I learned an awful lot from him. . . I don't think there were too many people before the new curriculum who emphasized concept . . . From him, I guess I learned to start off slowly, and build, and use some props . . . So that fed into what I like to do anyway, and he just, you know, there were more strategies there, but he kind of slowed me down; when you'd start a concept, and then as the students were really comfortable with it, then you could pick up the pace, so it was that kind of timing and stuff that was a big help.

Ryan had similar positive experiences at his present school and attributes much of success in the area of assessment to a colleague that he has worked closely with for most of his career. He credits this colleague with the development of cafeteria testing, previously discussed in Chapter 5.

*Encouraging dialogue with teachers from all levels.*

Andrea was the only participant to discuss the virtues of dialoguing with teachers from all levels: elementary, middle, and high school. In her case, a group of female mathematics teachers from all levels invited Andrea to their informal meetings where they discussed a wide variety of issues pertinent to their own teaching. She discovered that "in many ways, teachers at elementary and junior high are ahead of us on the assessment game" and that they don't feel the same constraints in terms of the delivery of curriculum. "I just think there's a little more freedom in how you (elementary and middle school teachers) can choose to put it together, and get at the concepts. I haven't found that freedom in high school. Or maybe I'm afraid to try it." From Andrea's perspective, this was a wonderful opportunity to discuss issues relevant to her own teaching and assessment practices.

*Teacher committees comprised of high school mathematics teachers.*

Denise indicated that working on a school board committee with other high school mathematics teachers provided the opportunity for increased teacher dialogue. With no free periods and few math colleagues within her school, committee work was one of the few opportunities for her to discuss teaching and assessment issues relevant to her classroom. She stated that her work on the board's Grade 10 Implementation Team was both informative and fun. On this committee she had the opportunity to work with three of the most experienced and motivated Grade 10 teachers in the board. She valued their conversations while in formal meeting and during informal get-togethers. Since Denise is responsible for a large number of courses in a school that is small compared to many in the province, it is understandable why she believes that committee work is a critical component to increasing dialogue.

From Andrea's perspective, not all committee work has to be created or sanctioned by the Department or school boards. In her case, several high school mathematics teachers in the metro area created an informal committee designed to address Grade 12 curriculum and assessment issues. She said the following.

We had a meeting, a couple of meetings in fact, the Halifax leaders of all the high schools, math leaders of all the high schools in HRM, to try to figure out ways of addressing the Grade (12), after the January exam, how do we do a better job?

This group of individuals was ultimately responsible for developing the independent study used at several high schools within the Halifax Board. This unit was originally designed to address the perceived lack of time for delivery of curriculum. Assessment techniques for this unit were discussed until a unified form of assessment was ratified by the committee.

*Participation in external mathematics organizations.*

Andrea has very proud of the work she had done for two national mathematics organizations. She felt that these were positive professional development opportunities where she was allowed to exchange ideas with teachers and professors from all over the country. She does acknowledge that she was initially intimidated when she joined these groups, but found that they were very accepting and eager to hear her suggestions and/or concerns.

I've worked as a member of the (name of organization) for, I guess it's going on six or seven years now, and that again, is a great chance to talk math with people who are keen to do math. . .so the first time . . you're sort of nervous about whether or not you can measure up. Well, it's just so relaxed, and they're so accepting, and so keen and all the rest, it was just great . . . You talk about professional development.

Andrea made the following statement regarding the other national organization.

I also got a chance to go to . . . (name of organization). . . It was more maybe insights and motivation, rather than actual . . . professional development that I could take into the classroom, but it just was a very healthy perspective on what should be done to improve math education in Canada. . . Their focus, is that you want as many students as possible to do as much math as their potential allows, as compared to what I think we sometimes get here, which is just you know, being blamed by the universities because the kids aren't measuring up.

The participants' recommendation that increasing teacher dialogue is a valuable way to introduce and support the use of new practices is supported in the research literature. Through discussions with peers, teachers can discover the benefits of using a specific practice (Goodman & Dean, 1982), and develop strategies for dealing with potential obstacles whether they are at an individual, school, or board level (Cooney, 1994, Clarke, 1994). Research contends that when knowledge is obtained through discussion in a collegial fashion, teachers are more likely to take ownership of that knowledge and are more likely to integrate into their existing practices (Clarke, 1994). Lastly, teacher dialoguing can result in networking and support groups that are critical when dealing with the emotional and intellectual problems associated with adopting new practices (Moles as cited in Clarke, 1994)

Although all of these participants had opportunities to dialogue with other teachers, they recognized that, in many cases, they had to pursue these opportunities by volunteering for committee work or participating in conferences. In other cases, they felt that they had to create these opportunities by forming informal teacher committees designed to address specific

curriculum and assessment issues pertinent to their own practices. These seem to be appropriate measures when one considers that research states that 47% of U.S. high school teachers spent less than one hour a month meeting with colleagues on curriculum and instruction (Moles as cited in Clarke, 1994).

### *Summary*

To increase the number of assessment strategies employed by teachers, the participants suggested that additional teacher support through professional development should be supplied and that opportunities for teacher dialogue within schools and boards should be increased. The following list summarizes the different participant recommendations regarding professional development (PD).

- (1) PD should be gradual and incremental. This would allow teachers to reflect upon what they have learned. A PD session should concentrate on a limited number of teaching and assessment strategies. The participants contend that supplying numerous teaching and/or assessment strategies that may appear in several sections of a courses curriculum can be overwhelming for the teacher.
- (2) PD should be long-term. If the PD is gradual and incremental, it is going to take much longer to cover the same number of recommended teaching and assessment strategies. This also allows teachers to return to future PD sessions and discuss how successful they were implementing strategies and/or materials covered in previous sessions.

- (3) The individuals conducting the PD session should be recognized experts in the material that is being presented. These individuals should be actively and successfully using the strategies and materials presented in the session. They should not be newly trained individuals as is presently done with the "train-the-trainer" model.
- (4) Teachers should have the opportunity to examine current research that supports the use of the new strategies and/or materials, and opportunities to independently investigate current research.

In terms of increasing teacher dialogue, the participants made the following recommendations.

- (1) Mathematics departments within schools should create opportunities and a positive environment that encourages collaborative work and dialogue between all teachers in the math department.
- (2) Teachers should be encouraged to participate in mathematics committees comprised of teachers from all levels; elementary, middle, and high school levels. This allows all members to better understand the initiatives occurring at those levels, and the implications of these initiatives their own teaching and assessment practices.
- (3) Teachers should be encouraged to sit on committees comprised of other high school teachers. Whether these are formal curriculum and/or assessment committees, or informal committees create by groups of motivated teachers, they all serve the purpose of increasing teacher dialogue, and in turn, increase teacher exposure to a variety of assessment practices.

- (4) Teachers should be encouraged to join and participate in external mathematics organizations such as the Waterloo Mathematics Writing Committee or the Canadian Math Society where they have opportunities to discuss issues with teachers from all areas of our country.

## Chapter 8 Conclusions

### *Conclusions*

This qualitative study was designed to examine the assessment practices used by four Grade 12 mathematics teachers in the province of Nova Scotia and to gain insight into the factors that influenced the use of such practices. The selection of potential participants was made by a former mathematics consultant. It was believed that this individual, who was knowledgeable with recent trends in assessment, would be able to identify teachers who have adopted and embraced the new curriculum and the recommended assessment practices. From the list of potential candidates, four were chosen by the researcher, based on their availability and proximity to the researcher. Each participant was interviewed for 1 to 1.5 hours on a variety of questions primarily concerned with assessment however, questions regarding their conceptions of mathematics and teaching practices were also asked. The four participants came from different backgrounds and schools, and were at different stages in their careers, however, they shared similar views as to purpose of and definition for assessment. Although they all used a wide variety of assessment techniques, not all used the same techniques and when it came to shared techniques, they had not always experienced the same degree of success. All of the participants had endeavored to use assessment practices that complemented their own conceptions of mathematics and teaching practices, while also abiding to Department and board policies regarding the delivery and assessment of the prescribed curriculum.

After careful analysis of the data, three broad, yet common, themes emerged from participant's interviews. These themes focussed on:

- (1) the unique and innovative alternate assessment practices used by the participants,
- (2) participant concern regarding the direct and indirect influence of Board and Departmental policies on assessment practices, and

- (3) possible techniques for exposing teachers to a greater number of varied assessment techniques.

Although the participants had used a wide variety of assessment techniques, four techniques emerged that were considered unique and/or innovative, and are therefore worthy of further examination.

- (1) Pair Quizzes and Assignments

Two of the participants, Denise and Andrea, were strong proponents of pair quizzes and assignments. From their perspectives, this form of assessment was fair, acknowledged the diversity among students, and fostered self-esteem and self-confidence. Weaker students who were struggling with concepts were more likely to ask questions and persevere when they were asked to complete this less threatening form of quiz or assignment.

- (2) Independent Study Unit

Andrea and Craig initially introduced the independent study unit when they, as well as colleagues, were concerned that the curriculum could not be completed in the allotted time. However, during the development and implementation of these units, they recognized that there were additional benefits to this form of assessment beyond merely allowing students to complete the prescribed curriculum. Such units allow students to take greater ownership of their learning while still providing adequate support and incentives. Both Andrea's and Craig's units were designed such that assessment occurred throughout the unit, rather than solely at the end of the unit. This served as feedback to students as to their progress with the new concepts. It also motivated students to complete the material in a timely fashion, rather than procrastinating and attempting to learn the concepts in the last few days. Ultimately

this valuable assessment tool for teachers served as a valuable learning tool for students.

### (3) Cafeteria Testing

Ryan was a strong proponent of cafeteria testing, a form of assessment developed with one of his colleagues at his present school. With this form of testing, students are given a 50 point test where 30 points are derived from a series of questions of varying levels of difficulty and point values. More precisely, there are three questions, each with a part (a), (b), and (c), worth 6, 8, and 10 points respectively. The 6 point parts are more procedural in nature while the 10 point parts are problem solving questions, however all three parts tested the same mathematical concepts. The students were asked to complete one of the three parts. If they chose the procedural 6 point part, the best they could hope to obtain was 6 points out of 10. If they chose the challenging 10 point part, they might be able to obtain 10 points out of 10.

Ryan recommended this form of assessment for it clearly conveyed the level of sophistication one expected the student to obtain without unfairly penalizing all students in the class. Since the student selected the type of question they wished to complete, a greater number of high level questions could be incorporated into the test without jeopardizing the marks of some of the weaker students. Technically, a weaker student could select all the lower level procedural questions and still obtain a mark of 60% on that portion of the test.

### (4) Reflective Self Assessment Prior to Test

Ryan created a four step assessment process that ultimately taught students how to identify the important concepts in a particular section of material and then prepare for

an upcoming test on those identified concepts. Initially the teacher is the driving force in creating review materials prior to the test, however the students discover through classroom discussions how such materials are developed. In the later stages, students develop, complete and assess their own review materials. The students are also asked to supply written explanations that identified their rationale for a particular question and/or strategy to complete that question. Ryan's development of such an assessment tool was designed so that students could take greater ownership of their own learning and identify the underlying concepts and interconnections. This was done in an attempt to improve student learning, and not merely to improve test results.

All four participants expressed concerns regarding Departmental and School Board policies that directly or indirectly affected their use of particular assessment practices in the classroom. The first concern centered on the perceived lack of time to deliver and assess curriculum. The second concern focused on the types of assessment that the province deemed authentic.

#### (1) Perceived Lack of Time

The participants identified several policy decisions that created time constraints in the classroom, which ultimately effected the delivery and assessment of curriculum. These policy decisions focused on the issues of (1) the requirement to use discovery learning, (2) the implementation of semestering, (3) policies on absenteeism, (4) introduction of out-come laden curriculum, and (5) the reduced timetable for the scheduling of exams.

Although the participants recognized the merits of discovery learning, they did feel that the Department's decision to make this form of learning a fundamental component of the new curriculum was contributing to the lack of time. Discovery

learning, from their perspectives, takes more time; time that may not have been adequately factored in during the development of these new courses.

The Departmental decision to mandate semestering province-wide was also creating issues associated with time. Fewer periods, although much longer in length, did not serve the learning needs of most students. From Denise's perspective, too many students were being left behind as she attempted to deliver curriculum within the time constraints of this scheduling option. She was also concerned that the teacher workload associated with semestering was extremely high and could ultimately lead to teacher "burn-out". Craig was concerned that semesters had forced him to become more linear in the delivery and assessment of curriculum.

The third issue centered on board and school policies regarding absenteeism. Andrea was troubled with her board's policy of canceling buses during inclement weather. Although only a small portion of the school population should be directly effected by such a cancellation, a far greater number of students failed to attend. With reduced attendance, Andrea felt that she could not continue to teach and assess as she would on a regular school day. From the board's perspective, teaching and assessment were to continue on such days, but, from Andrea's perspective, this was not the case.

Denise's concern regarding absenteeism focused on her school's policy of excusing students for extra-curricular events as it pertained to the end of the school year. She was troubled by the frequent absences occurring at the end of the second semester prior to provincial exams. These sanctioned extra-curricular activities were adversely effecting her delivery and assessment of curriculum and the province's attempts to assess the curriculum. She felt that a more coordinated effort should be made at the school to insure that students are attending classes during this important segment of

the school year. Although Andrea and Denise raised different issues associated with student absenteeism, they did agree that missed classes in a semestered system were far more detrimental than those in a non-semestered system.

The fourth issue was the development and implementation of curriculum that the participants perceived as outcome-laden. All four participants felt that they had become consumed with delivering the outcome-laden curriculum that they didn't have the opportunities to introduce alternate assessment practices that they valued. Denise had abandoned presentations. Andrea had reduced the problem-solving component of her course and Ryan had temporarily stopped using cafeteria testing. From Craig's perspective, the extensive number of outcomes provide little opportunities for teachers to use their professional judgement to implement extension activities and alternate assessment practices.

The fifth and final issue was raised solely by Craig and was concerned with the Department's policy of restricting the number of days for final exams. This time restriction meant that Craig had to forgo the use of the collaborative component on his final exam. The curriculum and resources recommended group work so Craig felt that an assessment technique should be created to compliment this recommendation. The collaborative component to the final exam was his answer to this issue. In the end, he was very troubled that he had to abandon this form of assessment solely based on the Department's examination scheduling policy. He perceived that this policy was superceding his own professional judgement regarding fair and appropriate assessment.

## (2) Defining Authentic Assessment

The Department of Education expanded upon the definition for authentic assessment to include the stipulation that the assessment must also be directly linked to a curriculum outcome. This was the contentious issue for all of the participants. Using this definition, it meant that marking homework to determine if it was completed was now considered as a non-authentic form of assessment. From the participant's perspective, it also meant that mathematical concepts that were no longer directly tied to an outcome could not be taught.

For these teachers, homework had been a valuable learning, assessment and motivational tool, and they feared that the implementation of this new definition for authentic assessment was going to negatively effect their existing homework policies. If they couldn't assign marks for merely completing the homework, how could they insure that students would attempt the work so that the teacher could received the necessary feedback on individual student progress? The participants decided, that under this new definition, they could select and assess one or two of the assigned homework questions so that a mark could be assigned. By doing so, they were adhering to Department policy without compromising their own beliefs regarding the merits of homework.

Under the Department's expanded definition for authentic assessment, Craig felt that he can no longer deviate from the curriculum to teach topics that in his professional judgement were relevant or pertinent. Such is the case with his lessons on income tax. He felt that this assessment policy, that were initially designed to effect his assessment practices, were also meant to control the material he taught.

To increase the number of assessment strategies employed by teachers, the participants suggested that additional teacher support through professional development should be supplied and that opportunities for teacher dialogue within schools and boards should be increased.

#### (1) Professional Development

The participants made several recommendations regarding professional development (PD). They felt that PD should be long-termed and sustained. Changes in assessment and/or teaching practices takes a long time and professional development should reflect that by being comprised of numerous interconnected sessions. The goal of each PD session should be to make small incremental changes. Presenting one or two ideas or techniques per session would be far more beneficial to teachers versus attempting to introduce a wide variety of ideas or techniques. They felt that teachers needed time to digest and use the materials presented within each session. The PD sessions should be conducted by professionals who are truly experts in that area. If teachers are to learn about a new assessment technique, they need an informed and experienced individual to explain the rationale and implications of this form of assessment, and also provide suggestions on how it can be successfully integrated into their classroom practices. A recently trained individual will not suffice. The last recommendation regarding professional development came from Andrea. She felt that teachers needed access to research findings regarding the issue of assessment. If teachers had the opportunity to examine and further investigate such findings, then they would be exposed to a greater number of assessment techniques and may implement them into their own assessment practices.

## (2) Increasing Teacher Dialogue

All of the participants stated that being able to talk to fellow mathematics teachers regarding issues of assessment was critical in the development of their own assessment practices. They felt that all teachers should have such opportunities to dialogue with other teachers if one wished to expose these teachers to a greater variety of assessment techniques. The participants suggested that mathematics departments within schools should encourage collaboration and dialogue amongst their mathematics teachers. Teachers should be encouraged to sit on mathematics committees comprised of senior high teachers and/or teachers from different grade levels. The participants also recommended that teachers become involved with external mathematics organizations like the Canadian Mathematics Association. All of these suggestions ultimately increase teacher dialogue and may expose teachers to a greater number of assessment techniques.

The study identified the assessment practices used by four Grade 12 mathematics teachers, and their rationale for using such practices. It also allowed the participants to raise concerns and offer recommendations regarding the issue of assessment. Many of these concerns and recommendations were supported by research.

### *Implications*

This project was designed to tell the stories of four Grade 12 mathematics teachers as these stories pertain to the area of assessment. It is anticipated that teachers who read this thesis will be exposed to a variety of assessment techniques and the rationales for selecting each. The contexts and complexities associated with each of these techniques and rationales are clearly stated and no attempt is made to generalize that certain assessment practices should be shared by all teachers. Rather, this thesis allows readers to critically analyze their own assessment

practices, and possibly change factors or situations that directly or indirectly influence these practices.

For readers directly affiliated with the Nova Scotia Department of Education or in executive roles at local school boards, the findings of this thesis have a different significance. The four participants identified several policies that were adversely affecting the delivery and assessment of curriculum. The policies of greatest concern focussed on the issues of semestering, outcome-laden curriculum, absenteeism, and models for professional development. With only four participants, this study cannot conclude that these concerns are common amongst most teachers in the province, however, these concerns should be investigated further. A quantitative study maybe the best mechanism to determine how pervasive these concerns are.

#### *My Teaching Experience as It Pertains to the Findings*

Most educational research leaves the author out of the text; the researcher's judgements, biases, and evolving ideas are not include as part of the report. The omission is not the result of forgetfulness, but rather reflects the assumption that to present data that will be convincing and deemed legitimate, attempts must be made to bracket out the subjective. The illusion created by bracketing can be convincing. However, the author is part of the research not only because the questions posed reflect a focus on one set of concerns rather than another, but also because the constructs developed (i.e. organization of the data) and even the form and style of communication all are linked to the perspective and orientation that the author brings to the research project. For research to be authentic, the relationship between what is being said and the person(s) doing the talking must be apparent. (Gitlin & Russell, 1994, p.187)

My own teaching experience as it relates to this study of assessment practices should not be considered data. However, my experience does influence the direction of the study and, to a lesser extent, the interpretation of the data. This is not to say that other researchers conducting a similar study would not have identified similar themes and reached similar conclusions, but to omit my experience could be perceived as an attempt to maintain the illusion that this study, like any other study, is totally objective. For these reasons, my experience as it relates to the findings for this study, have been included in this chapter.

*Reflecting on Chapter 5.*

In Chapter 5, the participants' conceptions of mathematics and views on assessment were initially examined, however, alternate assessment practices recommended by the participants were the primary focus.

My own view of mathematics is similar to those of the participants. From my perspective, math is a highly creative discipline although that may not always be reflected in my teaching and assessment practices. Within my school, curriculum is delivered with little opportunity to explore the beauty of mathematics outside of an outcome-laden curriculum. However, I have had a few professional development opportunities that have allowed me to "explore" mathematics outside the context of curriculum. Masters courses, courses I have taught at the university level, and a NCTM conference I attended several years ago, have given me a more global view of mathematics.

Mathematics, from my perspective, requires that one understands how concepts can be applied to a given situation, the origin of such concepts and the interconnectiveness of different concepts. Like Andrea, my poor memory impedes my usage of defined procedures or algorithms therefore,

I rely on understanding to bridge the gap between different concepts. We also agree that problem solving is an integral component that fosters such understanding. Like Ryan, the practicality of mathematics as it is used to describe many real-world applications, is of great interest. These applications can be used to bridge conceptual gaps and further understanding.

Lastly, I believe, like Andrea and Craig, that mathematics requires perseverance and active participation. Mathematics is not an observer's sport. You must be engaged and remain focussed if you wish to find some level of success in mathematics. You may have to attempt several strategies before one finds a strategy that is successful. This may require that one goes beyond traditional paper-and-pencil techniques. Individuals may need to use technology, simulations, scale models, and/or inductive reasoning to solve problems.

Prior to this study, my own definition of assessment was narrow, compared to those of the participants. It was not as continuous and dynamic as proposed by literature and I did not engage a wide variety of assessment techniques. Although my assessment practices required that students demonstrate mathematical literacy, complete higher level questions, work collaboratively on occasions, and understand the interconnectiveness of concepts, these practices did not include journals, portfolios, research projects and presentations. Assessment occurred on a regular basis and did use a variety of techniques but not to the degree of the participants.

In Chapter 5, four alternate assessment practices were identified and recommended by participants: (1) pairs quizzes and assignments, (2) independent study projects, (3) cafeteria testing, (4) reflective self assessment prior to a test. How do these recommended practices compare to those used in my classroom?

Like Andrea and Denise, I am a proponent of pairs quizzes and assignments. For students, this form of assessment appears less intimidating because their responses occur after much deliberation, and have usually been checked by their partner. From my perspective, this form of assessment encourages communication and forces students to reflect upon their own understanding of the concepts. Denise felt that groups of three or four were, in some cases, detrimental to the group members. . She contended that in larger groups, students sometimes choose not to participate for a variety of reasons. Unlike Denise, I support the use of group quizzes and assignments. To alleviate the problem she raised of lack of participation, I implemented an evaluation scheme that encourages participation. Prior to the group quiz or assignment, the students are informed that only one paper from the group will be marked and each group member will receive the same mark based on that one paper. The paper will be randomly selected so it is imperative that all group members participate and insure that their partners obtain the same answers. If they attempt to leave a member behind, then they run the risk of that paper being selected and potentially having the group receive a poor mark. To insure that time doesn't become an issue, additional time is provided either the next day and/or during lunch break. By doing so, students will more likely focus on completing the task together, rather than worrying about the time.

From my experience, group and pairs tests and assignments are beneficial to the weaker students for the same reasons identified by Andrea and Denise, however, there are two benefits that have not been mentioned. These forms of assessment allow one to raise the level of questioning. More challenging problems can be presented since the students are permitted to exchange ideas and time is not a major factor in this form of assessment.

The second perceived benefit is associated with the time required to evaluate these assessment items. If a teacher is grading group quizzes or assignments, they are only marking 1 of 2, 1 of 3

or 1 of 4 assignments, based on the grouping. This means that the feedback to students can occur much more quickly, and the teacher can create more assessment tasks throughout the term, without creating a huge workload for themselves. However, if only one paper is being marked, then it is imperative that students are given time to meet and discuss their solutions when the marked paper is returned. This is the only way to insure that all parties receive the necessary feedback.

Like Andrea and Craig, I am a proponent of independent study units. When our school adopted the semester schedule, an independent unit on polar coordinates was integrated into my PreCalculus 12 course. Initially the decision was made primarily based on the issue of time. I was concerned that the students would be unable to finish the program in the allotted time. As it turned out, we did have enough time, however, the students were still asked to complete the section before the end of the semester with minimal assistance from myself. Their efforts and resulting understanding of the independent study concepts were more than satisfactory. They had taken ownership of their own learning. This experience appeared beneficial to the students so it has remained as part of my PreCalculus program. Allowing students to take responsibility for their own learning is critical and probably best stated by Wheeler (2000)

The teacher can only begin to be effective if he respects each child and works for each child's autonomy. We have made considerable adjustments in our beliefs and attitudes about children and teaching. We know, for example, that education is not concerned with filling children with knowledge or slotting them into a role in society. We believe that children can take some responsibility for their own learning, and that we do not need to programme them as if they were machines. (p.58)

From my perspective and those of Andrea and Craig, these independent study projects and related assessment items are valuable learning and assessment tools.

Cafeteria testing requires students to select the questions they wish to complete, however, the questions they select from deal with the same concept but differ in complexity. In my classroom, students are routinely asked to select a specified number of questions from a larger bank of questions on tests and exams. For example, students might be asked to complete eight of the ten questions. By creating this sort of assessment activity, I feel that a few higher level questions can be asked without causing a great deal of stress to the students and without making them feel that the test was unfair. After all, they could bypass one higher level question in favour of another high level question. These higher level questions, required by the Department of Education, force students to apply a variety of concepts and/or strategies in an attempt to reveal their level of understanding. This conjecture is supported by research. "Only if the questions assess the degree to which pupils understand the principles which underlie the methods they use, will the development of this understanding be the focus of teaching and learning." (Clausen-May, 2000, p.32) Cafeteria testing asks students to select their own questions and, from Ryan's perspective, has similar benefits. What makes it unique is that the format doesn't allow the student to bypass a particular concept, as is the case with my assessment technique described above. With cafeteria testing, three questions ranging from routine to challenging address the same mathematical concept. This progression of questions allows the students to better understand the level of mastery the teacher hopes one will obtain with that particular mathematical concept. This progression also allows higher level questions to occur with greater frequency than on tests where students are merely asked to select a specified number of questions from a larger question bank. Unfortunately, I have never encountered the cafeteria testing in the workplace or during my literature review for this thesis, but I do feel it warrants further investigation. The underlying principles for this form of assessment do conform to the principles for assessment addressed in Chapter 2 of this thesis. My only concern with this form of assessment is the issue of time for the teacher. The teacher is almost creating three different tests embedded within one. Creating such a test would be a demanding task when one considers

that the (a), (b), and (c) components of each question must be testing similar concepts. This may be more practical for Ryan since he teaches in a large high school where there is a lot of interaction between teachers. They may have more opportunities to exchange materials and ideas, and that may mean that the development of cafeteria testing is more manageable.

From my perspective, Ryan's reflective self-assessment prior to a test was an innovative technique for students to prepare for an upcoming test. Although I have used review questions prior to a test, I had never asked students to develop their own review materials and justify their selections. This is an assessment practice that I hope to use in the future.

#### *Reflecting on Chapter 6.*

In Chapter 6, the participants raised concerns over Departmental and school board policies that were effecting their assessment practices. The first concern centered on the lack of time to deliver and assess curriculum. The second concern focused on the types of assessment that the Province deemed authentic.

The participants identified five areas of concern associated with the lack of time to deliver and assess curriculum. These were (1) discovery learning, (2) semestering, (3) outcome-laden curriculum, (4) absenteeism and (5) scheduling of exams. Discovery learning, from the participants perspective and from my own, does have its merits but can be time-consuming. In the Grade 11 mathematics courses, I use most of the investigations because the course itself appears manageable in terms of the number of outcomes and the investigations are guided, meaning most students can successfully complete them and discover the necessary concepts. However, in the PreCalculus 12 program, I use discovery learning to a lesser extent. This occurs for two reasons. In the first case, the PreCalculus 12 curriculum appears to have a greater

number of challenging concepts compared to the Math 11 programs; concepts that are not always accessible through discovery learning. In the second case, the investigations in the approved text are more open-ended, making it more difficult for students to discover the underlying concept in the allotted time. In an attempt to alleviate this problem, several investigations have been rewritten to make them more guided in nature. I cannot comment on discovery learning as it applies to academic math 12 or advanced math 12 because those courses have never been part of my teaching assignment.

The perceived lack of time associated with semestering has been a major concern for me over the last four years. During the 2002/2003 school year I wrote a lengthy letter to my principal regarding the issue of semestering. At the time, the Department was considering whether to mandate semestering throughout the province and my principal was considering this scheduling option. My letter identified several problems with semestering as it applied to the teaching of mathematics. He agreed with my findings and those of other colleagues and decided to remain with the non-semestered option. However, in the 2004/2005 school year, all schools in the province were to be semestered based on a mandate from the Department of Education. Although I have been able to deliver and assess the curriculum in this environment, it has been challenging for me and my colleagues. My biggest complaint regarding semestering focuses on the longer periods. In my personal experience, longer periods can create attention issues for even the advanced students, particularly during double periods. Creating lessons and assessment activities that can engaged a group of thirty young adults for 100 minutes or more is extremely challenging for even the most experienced teacher. And even if the class is 50% longer, it doesn't mean that the teacher can now cover 50% more material. Students need time to play with and think about newly acquired concepts, a luxury that doesn't appear to exist in a semestered mathematics classroom.

Andrea and Denise raised concerns regarding absenteeism as it pertains to the delivery and assessment of curriculum, particularly in a semestered system. Similar issues exist within my own school. On any school day, there is often at least one student missing in each class and the responsibility of assisting a student as they attempt to make up material missed in a 60 minute class can be daunting. On many lunch hours, you are required to repeat lengthy components of previous lessons to assist these students who have missed classes. Since many of the lessons are investigations and require collaboration with other students, it seems unfair for a teacher to send a student home and expect them to make up the missed material on their own. They need the teacher's assistance, so ultimately I find that my lunch hour is consumed with providing help to these individuals. Providing such assistance for students who have missed for medical reasons is fine, but when students over-commit themselves to school sanctioned events and repeatedly miss class, that can be extremely frustrating for their teachers.

From the participant's perspectives, the Grade 12 curriculum appears outcome-laden and this contributed to their frustrations regarding the perceived lack of time. Since I have not taught either the academic or advanced 12 programs, commenting on this issue is inappropriate. I can say that the Grade 11 programs and PreCalculus 12 program appear manageable in terms of the number of outcomes, however, there is little time to explore mathematics, related to, but not defined by the curriculum. Every minute appears to count. This can be troubling for teachers because they are unable to exercise professional judgement to the same extent if the time to deliver the defined curriculum is tight. For example, in my PreCalculus 12 course, although problem solving occurred throughout the course, we previously dedicated a week and a half solely to problem solving. The textbooks were temporarily put in storage as the students worked in groups to complete a wide variety of challenging questions. This opportunity to deviate from the curriculum no longer exists in a system that focuses on the delivery of specific outcomes. From a personal perspective, there are so many outcomes to be completed in the allotted time

that there is little opportunity for teachers to use their professional judgement to implement extension activities and engage in alternate assessment practices.

Craig had commented on the Department's decision to limit the number of days for final exams. He was troubled that this practice effectively eliminated the collaborative component of his final exam. Although I had never been troubled by this Departmental decision in the past, in light of Craig's comments, it may be time to revisit this decision.

All four participants were concerned with the Department's definition of authentic assessment; to be authentic, the assessment must be directly tied to an outcome. This means that merely assessing the completion of homework, or assessing concepts not found in the curriculum was not considered authentic.

My personal views regarding homework align closely with those of the participants and therefore similar concerns arose regarding the Department's definition of authentic assessment. Although homework is a valuable assessment, from my perspective, it is also a valuable motivational tool. As I learned in my first year of teaching, if you do not check the homework, they will not do it, and as a result perform poorly on subsequent assessment tasks. What was shocking was that this revelation was made during my first year while teaching the Grade 11 advanced mathematics students, who I expected would have the best work habits in the school. After that, I decided to implement a homework policy. For my twenty year career, I have checked homework to insure that it is complete and correct. Students were expected to complete it on the previous night, bring it in on the following day, and correct it with the assistant of the teacher, a classmate, or by using one of the answer books. During that school day, the student would show me the completed work and it would be signed off on their homework sheet if it was complete and correct. This sheet was worth 10% of their term mark. As an added incentive, students, who had

completed the assigned homework prior to a quiz, were permitted to write the quiz as an open-book quiz. This worked wonderfully.

Initially when the Department of Education stated that marks were not to be assigned for merely the completion of homework, I was very concerned. Homework was an integral component to encourage students to take some ownership in the learning process; review newly acquired concepts, and identify their level of understanding with each of those concepts. If this valuable assessment and motivational tool were gone, how would the students and myself cope? Upon reflection, I realized that my homework policy could be modified slightly to meet the expectations of the Department. Presently I check to see that the work is complete but also identify two questions that will be checked thoroughly. These selected questions could be described as key assessment questions; reflecting the underlying concept(s) of the lesson or lessons. This assessment technique provides immediate feedback to my students and myself and allows one to decide whether additional work and time is required for that topic or with that individual.

The participants were also concerned that interesting and relevant concepts, like income tax, could not be incorporated into existing academic or advanced programs because they were not defined in the curriculum. If a concept could not be connected to an outcome, assessment of that concept is not considered authentic and therefore should not be done. This was most likely introduced to insure that teachers did not deviate greatly from the prescribed curriculum, however, from my prospective, my innovations in teaching and assessment practices arise from such deviations. Consider the calculus problem solving project that was introduced in my Calculus 12 course. In 1995, when I proposed and piloted my school board's locally developed Calculus course, I introduced a component called the Calculus Problem Solving Project. This project was in reaction to troubling observation I made regarding advanced level students. Too

many of these students had become accustomed to throwing projects together, typically a day or two before the due date, handing them in, and getting very reasonable and often excellent marks. Many students openly bragged how little work they had done to receive their mark. These students were not challenged by the work. I wanted to create a project that challenged them, required planning, and demanded skills beyond the typical pencil and paper skills they had relied so heavily on in the past. The calculus problem project was born. Each year, my calculus students had to design, build, and operate a device that could complete a specified task. It would have to be constructed of Popsicle sticks, and adhere to restrictions in terms of dimension and weight. This project was demanding yet on the day of the final competition, students were excited to compete. Many former graduates and their parents commented years later that they loved this project and hoped that I was still doing this with my students. In 2005, Calculus became a provincial course, rather than a locally developed course. As a result of this, curriculum with clearly defined outcomes was designed. Although the Calculus Problem-Solving Project was a valuable learning experience for the students, it could not be directly tied to a specific calculus outcome. Since this was the case, the decision was made to abandon the project in spite of my misgivings. Departmental policy on authentic assessment had adversely affected my choice of assessment practices.

### *Reflecting on Chapter 7.*

In Chapter 7, methods for exposing teachers to a greater number of varied assessment techniques were examined. The participants made two recommendations for improvements in this area. They focussed on increasing teacher support through the introduction of long-termed sustained professional development in both teaching and assessment practices, and on creating greater dialogue amongst teaches regarding assessment practices.

My opinions regarding professional development align closely with those expressed by the participants. Professional development should be long-term, sustained, and encourage gradual and incremental changes. The professional development sessions should include the rationale for impending changes as it applies to mathematics at a provincial level, and the supporting research findings should also be provided. The sessions should be given by an individual who is truly an expert in that area or practice, rather than an individual who has been recently trained.

Over a twenty year career, I have attended numerous professional development sessions however, only a few have significantly affected my teaching and assessment practices over the long term. Such was the case with the PD sessions primarily concerned with discovery learning conducted by the Department in the middle to late 1990's. The Department invested both time and money into creating numerous interconnected sessions to prepare teachers for the future implementation of the new curriculum. Much of the curriculum had not been completed however, from my perspective, the Department appeared to be taking a proactive approach in terms of PD. This proactive approach meant that impending changes could be presented incrementally and gradually, giving myself more time to reflect upon the benefits of using these new practices and attempt to integrate them into my own classroom prior to the implementation of the new curriculum. These PD sessions were wonderful learning experiences.

The other issue for the participants regarding professional development focussed on the model for delivery of PD. The participants, like myself, were troubled by the "train-the-trainer" model used by the Department. In 2003, I wrote the new inferential statistics unit for the Grade 11 program and the unit was quite unique in its approach. Rather than being asked to present a series of workshops around the province on this material, I was asked to conduct a two-day session for about thirty mathematics leaders from around the province. These people, although very intelligent, professional, and enthusiastic, had never seen or attempted to use any of this

new material. These leaders were now in the unenviable position of trying to become experts on this 100 page unit so that they could disseminate their knowledge to other teachers in their board.

In terms of teacher dialogue, this is one area where my own experience does not align with those of the participants. Although I believe that such dialogue can increase exposure to a greater number of varied assessment practices, I have had very few of these dialogue opportunities outside of infrequent PD sessions. This may seem quite unusual for a teacher who has worked in the same mid-sized high school for twenty years. Unfortunately in a school of this size, there is often little overlap between teaching assignments. For example, I am the only teacher responsible for Calculus 12, PreCalculus 12, and Advanced Math 11. From my perspective, this adversely affects teacher dialogue in two ways. If teachers do not share courses then they are less likely to meet with their colleagues and share ideas. In addition, the preparation for courses becomes a very isolating event, which ultimately creates some level of detachment between members of the mathematics department. The sharing of ideas often occurs when teachers have overlap in their assignments.

In closing, many of the participant concerns and opinions, directly or indirectly associated with assessment, were shared by myself. I was surprised, however, issues such as Individualized Program Planning, generous promotional policies, and exam exemption policies were not raised by any of the participants. These issues have indirectly affected assessment practices within my own classroom and school.

## References

- Association for Educational Communications and Technology. (2000). *Change in educational settings*. Retrieved October 16, 2003, from <http://ide.ed.psu.edu/change/ely.htm>
- Berg, B. (2004). *Qualitative research methods for the social sciences*. Boston: Allyn and Bacon
- Boeree, C. G. (1998). *Qualitative methods workbook*. Retrieved April 4, 2006, from <http://www.ship.edu/~cgboeree/qualmeth.html>
- Bogdan, R.C. & Biklen, S.K. (1998). Foundations of qualitative research in education. In R.C. Bogdan & S.K. Biklen. *Qualitative Research for Education*, (pp. 1-48). Boston, Allyn and Bacon.
- Brown, T., McNamara, O., Hanley, U. & Jones, L. (1999). Student teachers' conceptions of mathematics. *Mathematics Teaching*, 167, 28-32.
- Buschman, L. (2001). Using student interviews to guide classroom instruction: An action research project. *Teaching Children Mathematics*, 8, 222-227.
- Centre for Research in Applied Measurement and Evaluation. (1993). *Principles for fair student assessment practices for education in Canada*. Retrieved March 21, 2004, from <http://www.2learn.ca/Projects/Together/fair.html>
- Clarke, D. (1994). Ten key principles from research for the professional development of mathematics teachers. In D. Aichele, & A. F. Coxford, *Professional Development for Teachers of Mathematics*, (pp. 9-21). Reston: National Council of Teachers of Mathematics.
- Clarke, D. (1997), *Constructive assessment in mathematics; Practical steps for classroom teachers*. California: Key Curriculum Press
- Clausen-May, T. (2000). Understanding assessment – the assessment of understanding. *Mathematics Teaching*, 171, 32-35.
- Cooney, J. C., Shealy, B. E. & Arvold, B. (1998). Conceptualizing belief structures of preservice secondary mathematics teachers. *Journal for Research in Mathematics Education*, 29, 306-333.

- Cooney, T. J. (1994). Teacher Education as an exercise in adaptation. In D. Aichele, & A. F. Coford, *Professional Development for Teachers of Mathematics*, (pp. 9-21). Reston: National Council of Teachers of Mathematics.
- Cooper, J.W. (2001). *Block scheduling: Is this right for America's public schools?* Retrieved May 3, 2006, from <http://www.johnwcooper.com/papers/blockscheduling.htm>
- De Lange, J. (1993), Assessment in problem-oriented curricula. In N. L. Webb & A. F. Coford. *Assessment in the Mathematics Classroom*, (pp. 197-208). Reston. National Council of Teachers of Mathematics.
- Boeree, C. G. (1998). *Qualitative methods workbook*. Retrieved April 4, 2006, from <http://www.ship.edu/~cgboeree/qualmeth.html>
- Dennett, D. (1998). *Postmodernism and truth*. Retrieved January 4, 2004, from [http://www.butterfliesandwheels.com/printer\\_friendly.php?num=13](http://www.butterfliesandwheels.com/printer_friendly.php?num=13)
- Ellsworth, J. B. (2000), *A survey of educational change models*. Syracuse. ERIC Clearinghouse on Information and Technology.
- Fennema, E. & Franke, M. L. (1992). Teachers' knowledge and its impact. In D. A. Grouws, *NCTM Handbook of Research on Mathematics Teaching and Learning*, (pp. 147-164). New York: Macmillan.
- Gitlin, A. & Russell, R. (1994). Alternative methodologies and the research context. In A. Gitlin. *Power and Method; Political Activism and Educational Research*, (pp. 181-202). New York. Routledge.
- Glesne, C. & Corinne (1999). *Becoming qualitative researchers*, New York: Longman.
- Goodman, P. S. & Dean, J. W. (1982). Creating long-term organizational change. In P. S. Goodman. *Change in Organizations*, (pp. 226-278). San Francisco, Jossey-Bass Publishers.
- Hawker, D. & Ollerton, M. (1999). National tests in mathematics: Two perspectives. *Mathematics Teaching*, 168, 16-25.

- Herrington, J. , Herrington, A. & Glazer, E. (2002). *Authentic approaches to learning assessment strategies: Beginning teachers' practice in classrooms* (Proceedings of the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education). Georgia. (ERIC Document Reproduction Service No. ED471766)
- Kenney, P. A. & Silver, E. A. (1993), Student self-assessment in mathematics. In N. L. Webb & A. F. Coxford. *Assessment in the Mathematics Classroom*, (pp. 229-237). Reston. National Council of Teachers of Mathematics.
- Leck, G. (1994). Queer relations with educational research. In A. Gitlin. *Power and Method; Political Activism and Educational Research*, (pp. 77-96). New York. Routledge.
- Lee, C. (2001). Using assessment for effective learning. *Mathematics Teaching*, 175, 40-43.
- Lesh, R. & Lamon, S. J. (1992). Trends, goals and priorities in mathematics assessment. In R. Lesh & S. J. Lamon. *Assessment of Authentic Performance in School Mathematics*, (pp. 3-15). American Association for the Advancement of Science.
- Linchevski, L. & Kutscher, B. (1998). Tell me with whom you're learning and I'll tell you how much you've learned: Mixed-ability versus same-ability grouping in mathematics. *Journal for Research in Mathematics Education*, 29, 533-554.
- Litherland, B. (1997). Reflections on the assessment of mathematics. *Mathematics Teaching*, 159, 10-14.
- Lubienski, S. T. (2000). Problem solving as a means toward mathematics for all: An exploratory look through a class lens. *Journal for Research in Mathematics Education*, 31, 454-482.
- Lyngard, L. (2004). *Scheduling and the new Ontario curriculum: Teachers' perceptions*. Retrieved May 3, 2006, from <http://www.oise.utoronto.ca/field-centres/TVC/RossReports/vol9no2.htm>
- MacIntosh, H. G. (1994). A comparative study of current theories and practices in assessing students' achievement at primary and secondary level ( Final Report prepared for the International Bureau of Education). Geneva. (ERIC Document Reproduction Service No. ED373099)

- MacLeod, A. (2002). *Exploring the contradictions and tensions in the lives of women family physicians: A feminist qualitative investigation*. Unpublished master's thesis, Mount Saint Vincent University, Halifax, Nova Scotia, Canada.
- Markovits, Z. & Sowder, J. T. (1994). Developing number sense: An intervention study in grade 7. *Journal for Research in Mathematics Education*, 25, 4-29.
- Marlow, E. (2000). Assessment in the mathematics curriculum. Missouri. (ERIC Document Reproduction Service No. ED443844)
- Middleton, J. & Spanias, P. (1999). Motivation for achievement in mathematics: Findings, generalizations, and criticisms of research. *Journal for Research in Mathematics Education*, 30, 65-88.
- Morgan, C. (2000). *Discourses of assessment – Discourses of mathematics* (Paper presented at the International Mathematics Education and Society Conference). Portugal. (ERIC Document Reproduction Service No. ED472098)
- Morgan, C. & Watson, A. (2000). *Teacher-assessment and equity* (Paper presented at the International Mathematics Education and Society Conference). Montechoro. (ERIC Document Reproduction Service No. ED472943)
- Morgan, C. & Watson, A. (2002). The interpretative nature of teachers' assessment of students' mathematics: Issues for equity. *Journal for Research in Mathematics Education*, 33, 78-110.
- National Center for Educational Statistics. (1991). Education indicators: An international perspective. Retrieved May 5, 2006, from <http://nces.ed.gov/pubs/eiip/eiipid37.asp>
- National Council for Curriculum and Assessment. (2006). *Homework*. Retrieved April 29, 2006, from <http://www.ncca.ie/index.asp?locID=363&docID=-1>
- National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.
- National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

- Newsome, K. & Thompson, T. (2002). Is state assessment a viable tool for reflection of classroom assessment. *Proceedings of the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*
- Noble, T., Nemirovsky, R., Wright, T. & Tierney, C. (2001). Experiencing change: The mathematics of change in multiple environments. *Journal for Research in Mathematics Education*, 32, 85-108.
- Nova Scotia Department of Education. (2000). *Atlantic Canada mathematics curriculum: Grade 12*. Nova Scotia: Author.
- Nova Scotia Department of Education. (2002). *Time to learn strategy: Instructional time and semestering*. Nova Scotia: Author.
- Nova Scotia Department of Education. (2006). *Nova Scotia students improve in language arts, Struggle in mathematics*. Retrieved June 28, 2006, from <http://www.gov.ns.ca/news/details.asp?id=20060505007>
- Peressini, D. (1997). Parental involvement in the reform of mathematics education. *The Mathematics Teacher*, 90, 421-426.
- Petit, M. & Zawojewski, J. (1997). Teachers and students learning together about assessing problem solving, 90, 472-477.
- Philipp, R., Flores, A. & Sowder, J. (1994). *Reflective practitioners reform school mathematics* (National Center for Research in Mathematical Sciences Education research review). Wisconsin. (ERIC Document Reproduction Service No. ED372930)
- Runnels, V. (2006). *Semestering or non-semestering? An overview of some evidence*. Retrieved May 3, 2006, from <http://www.colonelby.com/parent/semestering.htm>
- Scheurich, J. (1997). *Research method in the postmodern*. Washington, DC: Falmer.
- Schorr, R. Y., Firestone, W. A., & Monfils, L. (2003). State testing and mathematics teaching in New Jersey: The effects of a test without other supports. *Journal for Research in Mathematics Education*, 34, 373-405.
- Schram, T. H. (2003). *Conceptualizing qualitative inquiry*. Upper Saddle River, New Jersey: Merrill Prentice Hall.

- Secada, W. G. & Byrd, L. (1993). *School-level reform and the teaching/learning of mathematics* (National Center for Research in Mathematical Sciences Education research review). Wisconsin. (ERIC Document Reproduction Service No. ED370770)
- Seeley, C. (2005). *Using research to improve teaching*. Retrieved July 13, 2006 from [http://www.nctm.org/news/pastpresident/chat\\_041405.htm](http://www.nctm.org/news/pastpresident/chat_041405.htm)
- Seidman, I. E. (1991). *Interviewing as qualitative research*, New York: Teachers College Press.
- Senk, S. L. & Beckman, C. E. (1997). Assessment and grading in high school mathematics classrooms. *Journal for Research in Mathematics Education*, 28, 187-216.
- Shannon A. & Zawojewski J. (1995). Mathematics performance assessment: A new game for students. *The Mathematics Teacher*, 88, 752-757.
- Shank, G. (1995). *Semiotics and qualitative research in education: The third crossroad*. Retrieved April 4, 2006, from <http://www.nova.edu/ssss/QR/QR2-3/shank.html>
- Simon, M. S. & Tzur, R. (1999). Explicating the teacher's perspective from the researchers' perspectives: Generating accounts of mathematics teachers' practice. *Journal for Research in Mathematics Education*, 30, 252-264.
- Stainback, S. & Stainback, W. (1988). *Understanding and conducting qualitative research*. Retrieved April 4, 2006, from <http://gse.gmu.edu/research/tr/Trcomparison.shtml>
- Stallings, V. & Tascione, C. (1996). Student self-assessment and self-evaluation. *The Mathematics Teacher*, 89, 548-554.
- Swan, M. (1993), Assessing a Wider Range of Students' Abilities. In N. L. Webb & A. F. Coxford. *Assessment in the Mathematics Classroom*, (pp. 26-39). Reston. National Council of Teachers of Mathematics.
- Tahta, D., Pope, S., Winter, J., Pinel, A., Knights, G., Gorman, M., Hatch, G. & Wells, D. (1994). Coming up to Russian expectations. *Mathematics Teaching*, 146, 25-36.
- Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws, *NCTM Handbook of Research on Mathematics Teaching and Learning*, (pp. 127-146). New York: Macmillan.

Tierney, W. (1994). On method and hope. In A. Gitlin. *Power and Method; Political Activism and Educational Research*, (pp. 97-115). New York. Routledge.

Trends in International Mathematics and Science Study. (1999). *Mathematics benchmarking report, Chapter 6*. Retrieved April 29, 2006 from [http://timss.bc.edu/timss1999b/mathbench\\_report/t99bmath\\_chap\\_6](http://timss.bc.edu/timss1999b/mathbench_report/t99bmath_chap_6)

Valdez, G. (2004). Critical issue: Technology leadership: Enhancing positive educational change. Retrieved July 13, 2006, from <http://www.ncrel.org/sdsd/areas/issues/educatrs/leadrshp/le700.htm>

Van Den Heuvel-Panhuizen, M. & Becker, J. (2003). Towards a didactic model for assessment design in mathematics education. In A. J. Bishop et al. *Second International Handbook of Mathematics Education*, (pp. 689-716). Dordrecht. Kluwer Academic Publishers.

Webb, N. L. (1992). Assessment of students' knowledge of mathematics: Steps toward a theory. In D. A. Grouws, *NCTM Handbook of Research on Mathematics Teaching and Learning*, (pp. 147-164). New York: Macmillan.

Webb, N. L. (1993), Assessment for the mathematics classroom. In N. L. Webb & A. F. Coxford. *Assessment in the Mathematics Classroom*, (pp. 1-6). Reston. National Council of Teachers of Mathematics.

Wilson, L. (1994). What gets graded is what gets valued. *The Mathematics Teacher*, 87, 412-414.

## Appendix A: Letter to Participants

Date, 2004

Dear \_\_\_\_\_:

My name is David Pilmer and I am a candidate in the Master of Arts in Education degree at Mount Saint Vincent University. My thesis titled *A Qualitative Study of the Assessment Practices Of Four Nova Scotia Grade 12 Mathematics Teachers*.

Commencing in 1994 and over the span of seven years, the Atlantic Provinces Education Foundation (APEF) created a common mathematics curriculum at the secondary level. A significant amount of time, money, and resources were allocated to developing new student materials and inservicing teachers on the use of these materials and alternate teaching practices. Although some time was spent addressing assessment, it was disproportionately low, largely due to issues of funding. Only a few years after the implementation of this new reform curriculum, and the recent implementation of, and poor performance on, the provincial external exams, has assessment risen to the forefront. Nevertheless little is known regarding assessment practices of grade 12 mathematics teachers in the province of Nova Scotia.

My study is concerned with understanding the types of assessment practices used by four grade 12 mathematics teachers and gaining insights into the factors that affect the choice of such practices. A list of potential participants was supplied by a former mathematics consultant for the province of Nova Scotia. He/she believed that the teaching and assessment practices, and conceptions of mathematics for these individuals closely aligned with those endorsed by the Department of Education. By working with these teachers, I am hoping to obtain rich data that will allow me to complete an insightful analysis of assessment practices used by these individual teachers. I am not interested in contrasting their assessment practices nor generalizing that certain assessment practices should be shared by all teachers. My interest lies in telling their individual stories regarding assessment practices.

If you choose to volunteer for this research project, you will be asked to participate in one interview, approximately 1.5 hour in length. During that time you will be asked a series of questions on assessment which will include questions in the following categories:

- (1) your own conceptions of mathematics,
- (2) the assessment practices you use,
- (3) the rationale for using such assessment practices, and
- (4) the perceived effectiveness of these practices.

Since this study is concerned with assessment practices, you will be encouraged to bring any assessment items that you deem appropriate to the interviews.

I consent to participate in an interview: Yes [ ] No [ ]

I would like a copy of my comments e-mailed to me: Yes [ ] No [ ]

E-mail address: \_\_\_\_\_

I would like a copy of my comments mailed to me: Yes [ ] No [ ]

Mailing address: \_\_\_\_\_

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Name of Participant (printed): \_\_\_\_\_

Signature of Participant: \_\_\_\_\_ Date: \_\_\_\_\_

Signature of Researcher: \_\_\_\_\_ Date: \_\_\_\_\_

Signature of Thesis Supervisor: \_\_\_\_\_ Date: \_\_\_\_\_

Signature of Program Coordinator: \_\_\_\_\_ Date: \_\_\_\_\_