NOTE TO USERS

This reproduction is the best copy available.

UMI
Beliefs, Practices and Concerns about Authentic Assessment: Five Case Studies of Secondary School Mathematics Teachers

by

Christine A. Suurtamm

A thesis submitted in conformity with the requirements for the degree of Doctor of Education
Department of Curriculum, Teaching and Learning
Ontario Institute for Studies in Education of the University of Toronto

© Copyright by Christine A. Suurtamm 1999
The author has granted a non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of this thesis in microform, paper or electronic formats.

The author retains ownership of the copyright in this thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without the author’s permission.
Beliefs, Practices and Concerns about Authentic Assessment:  
Five Case Studies of Secondary School Mathematics Teachers  
Christine A. Suurtamm, Doctor of Education, 1999  
Department of Curriculum, Teaching, and Learning  
University of Toronto  

ABSTRACT

This is a qualitative study of five secondary school mathematics teachers as they attempt to employ authentic assessment strategies in their instructional practice. The study emerged after a review of research on the use of authentic assessment in secondary school mathematics and a recognition of a marked lack of detail in the literature concerning the beliefs, practices and concerns of secondary school mathematics teachers as they endeavour to change their assessment practices to align with current forms of mathematics instructional practice. Such detail is needed if educators are to understand the value, successes and difficulties of employing authentic assessment in a secondary school mathematics program and thus be able to offer appropriate assistance.

A qualitative approach, combining interviews, logs, collection of sample assessments, and classroom observation was used to gather the data over a one year period and to describe the five cases. These case studies record what the teachers are doing and why they are doing it, as well as the dilemmas and support that they encounter. Their use of authentic assessment includes a wide variety of techniques including journals, performance assessment, rubrics, checklists, and peer- and self-evaluation. The key messages that participants voice include the necessity for a
problems-based curriculum, the importance of developing a collaborative teacher culture, and the important role that administrators can play in facilitating change in assessment practices. Thus, the study has significant implications for teachers and for those concerned with the professional development and growth of teachers in the area of assessment.
ACKNOWLEDGMENTS

The writing of a thesis often feels like a lonely process. However, upon reflection, it is evident that there were many individuals who contributed along the way and made the completion of this thesis a reality. I wish to celebrate the patience, guidance, wisdom, support, and encouragement of all of my friends, colleagues, professors, and family to whom I owe so much.

I would sincerely like to thank the five participants in this study: Gwen, Julia, Dave, Miriam, and Luke. Their dedication and professionalism are to be admired. I truly appreciate their time and their willingness to share their experiences and their innovative ideas and activities.

My Thesis Supervisor, Dr. B. Kilbourn, was always ready when I needed support, encouragement, or just a chance to talk things out. His direction and advice have been invaluable, and his style of treating me as a respected colleague was greatly appreciated. The other members of my committee, Dr. M. Wahlstrom, Dr. E. Barbeau, and Dr. D. McDougall, also played key roles. Dr. Wahlstrom, my Advisor throughout both my graduate degrees, has constantly displayed his faith in my abilities. Dr. McDougall’s thoroughness in critiquing my first draft was very beneficial to refining my work. Dr. Barbeau’s enthusiasm for gaining a window into secondary school mathematics reform was refreshing and encouraged my project. I appreciate all of my committee members, as well as the external appraiser, Dr. A. Geddis, for making my Final Oral Examination a rewarding experience.
I would also like to thank my many friends and colleagues who have endured the past four years of my studies. I know that it meant that I could not always partake in activities with them. My good friend, Maureen Darling is to be commended for enduring my constant thesis talk when we got together to socialize. I would also like to thank my friend, Dr. A. Norrie, for his mentorship and encouragement throughout my studies. My Principals, Arnold Forde and Stella Voisin, were flexible and actually encouraged my balancing of research and teaching. Their friendship and leadership mean a great deal.

My two daughters, Liisa and Karen, make me proud for displaying constant support and an unselfish attitude when they had to tolerate my need to seclude myself to write. And my parents are to be thanked for teaching me to follow through on what I start.
# Table of Contents

## Abstract

## Acknowledgments

### Chapter One: Introduction
1.1 Setting the Stage
1.2 Statement of the Problem
1.3 Purpose of the Study
1.4 Significance of the Study
1.5 Limitations of the Study
1.6 Researcher: Personal Background
1.7 Plan of the Thesis

### Chapter Two: Review of Relevant Literature
2.1 Reform in Mathematics Education
2.2 Authentic Assessment
   - 2.2.1 General Discussion on Authentic Assessment
   - 2.1.2 Issues that Emerge with Authentic Assessment
     - 2.1.2.1 Reliability and validity of authentic assessment
     - 2.1.2.2 The Teacher's Role in Assessment
     - 2.1.2.3 Teachers' Knowledge and Beliefs
2.3 Similar Studies
2.4 Summary

### Chapter Three: Method
3.1 The Need for a Qualitative Approach
3.2 My Role as a Researcher
3.3 The Research Setting and Gaining Entry
3.3 Design of the Inquiry
3.4 Data Collection
   - 3.4.1 Preliminary Interview - Invitation to Participate
   - 3.4.2 First Interview
   - 3.4.3 Assessment Log Books
   - 3.4.4 Gathering Samples of Assessment
   - 3.4.5 Observation
   - 3.4.6 Focus Group Interview
   - 3.4.7 Final Interview
3.5 Description of the Data
3.6 Analysis and Interpretation of the Data
3.7 Ethical Issues
Chapter Four: The Case Studies

4.1 The Case of Gwen
   4.1.1 Gwen's View of Mathematics and Assessment
   4.1.2 Gwen's Use of Authentic Assessment
   4.1.3 Examples of Assessment/Problem-Solving Activities
   4.1.4 Support for Authentic Assessment
   4.1.5 Problems/Stumbling Blocks
   4.1.6 Summary

4.2 The Case of Julia
   4.2.1 Julia's View of Mathematics and Assessment
   4.2.2 Julia's Use of Authentic Assessment
   4.2.3 Examples of Assessment/Problem-Solving Activities
   4.2.4 Support for Authentic Assessment
   4.2.5 Problems/Stumbling Blocks
   4.2.6 Summary

4.3 The Case of Dave
   4.3.1 Dave's View of Mathematics and Assessment
   4.3.2 Dave's Use of Authentic Assessment
   4.3.3 Examples of Assessment/Problem-Solving Activities
   4.3.4 Support for Authentic Assessment
   4.3.5 Problems/Stumbling Blocks
   4.3.6 Summary

4.4 The Case of Miriam
   4.4.1 Miriam's View of Mathematics and Assessment
   4.4.2 Miriam's Use of Authentic Assessment
   4.4.3 Examples of Assessment/Problem-Solving Activities
   4.4.4 Support for Authentic Assessment
   4.4.5 Problems/Stumbling Blocks
   4.4.6 Summary

4.5 The Case of Luke
   4.5.1 Luke's View of Mathematics and Assessment
   4.5.2 Luke's Use of Authentic Assessment
   4.5.3 Examples of Assessment/Problem-Solving Activities
   4.5.4 Support for Authentic Assessment
   4.5.5 Problems/Stumbling Blocks
   4.5.6 Summary
Chapter 5: Analysis and Interpretation of Findings

5.1 Summary of Common Activities
5.2 Summary of Why These Teachers Do What They Do
5.3 Dilemmas
   5.3.1 Authentic Assessment Activities in a Content Laden Curriculum
   5.3.2 The Problem of Isolation
   5.3.3 Authentic Assessment and Reporting
5.4 Making Authentic Assessment Better
   5.4.1 Partnerships
   5.4.2 Resources
   5.4.3 Attitudes toward Professional Growth

Chapter 6: Reflections

6.1 Key Messages
6.2 Where do we go from here?
6.3 Reflections on my research

References

Appendices

A. Invitation of Participate
B. Gwen’s Authentic Assessment Activities
C. Julia’s Authentic Assessment Activities
D. Dave’s Authentic Assessment Activities
E. Miriam’s Authentic Assessment Activities
F. Luke’s Authentic Assessment Activities
G. Editing Quotes from Transcripts
Chapter One

Introduction

This is a qualitative study of five secondary school mathematics teachers as they attempt to employ authentic assessment strategies in their instructional practice. The study emerged from a noticeable lack of detail in the literature concerning the beliefs, practices and concerns of secondary school mathematics teachers as they endeavour to change their assessment practices to align with current forms of mathematics instructional methodology. Such detail is necessary if educators are to understand the value, successes and difficulties of employing authentic assessment in a secondary school mathematics program.

1.1 Setting the Stage

Mathematics education is undergoing vast and significant reform as well as reactions and challenges to this reform. In some circles, there has been a distinct paradigm shift and this shift is probably best characterized through the understanding of the seminal work, The NCTM Standards for Curriculum and Evaluation (NCTM, 1989) and its more current version Standards 2000 (NCTM, 1998). In mathematics education circles across North America these documents, commonly known as “The Standards”, reflect a new way of thinking about mathematics education.
This new approach to teaching mathematics was in part a reaction to *A Nation at Risk* (National Commission on Excellence in Education [NCEE], 1983), a report that illuminated the lack of students' understanding of significant mathematical concepts that would be needed for the twenty-first century. There were a variety of reactions to this issue. One reaction was a "back to the basics" approach, including an imposed system of standardized testing presumed to ensure a high level of mathematical competence.

The National Council of Teachers of Mathematics (NCTM), The National Council of Supervisors of Mathematics (NCSM), and The Association of State Supervisors of Mathematics (ASSM) had a different reaction. Research supported that children learn mathematics best when basic concepts are understood rather than memorized. True understanding would come from a more active and problem solving oriented approach to mathematics education. As well, it was perceived that problem solving ability and true understanding of mathematical concepts cannot be measured by standardized tests. Standardized tests tend to only measure mathematics skills rather than the understanding of mathematics concepts. The Council (NCTM, 1989) advocated that the basic goals of a sound mathematics education will enable all students to:

- learn to value mathematics,
- become confident in their ability to do mathematics,
- communicate mathematically,
- become mathematical problem solvers, and
- learn to reason mathematically (p. 5)
Mathematics education has been changing because of concern over how children are performing in mathematics. Using the NCTM Standards, and other supporting documents, mathematics educators are trying to improve the standards of both instruction and assessment by using the knowledge about how students learn mathematics and how mathematical knowledge is constructed. Naturally, as teachers' instructional practices change, so too must their assessment practices since the link between instruction and assessment is significant. Assessment is an essential tool for teachers to monitor progress, diagnose difficulties, and to evaluate both students' achievement and program effectiveness. Traditional assessment has primarily tested mathematical skills and procedures. Therefore, new assessment strategies are needed that focus on process, rather than product, to assess conceptual understanding and strategies for solving problems.

1.2 Statement of the Problem

Alternate assessment techniques raise issues that merit the attention of practitioners, educators and researchers. Teacher training in authentic assessment, the reliability and validity of authentic assessment, the variety of methods employed in authentic assessment and how they are employed are all concerns that emerge as new assessment techniques are implemented. At the secondary school level, authentic assessment is just beginning to appear in mathematics classrooms and little is known about these experiences. How teachers use authentic assessment, the problems they encounter, and the theoretical and practical issues that emerge are all questions that require further understanding and exploration. As illustrated in the literature review,
related research only skims the surface of the phenomenon of authentic assessment in mathematics. The intent of this study is to address this gap in the literature.

This study specifically addresses the issues associated with authentic assessment by describing and exploring mathematics teachers' experiences as they employ alternative assessment techniques in their secondary school mathematics program. It will describe the assessment techniques that teachers use, why they choose to use them, and how they use them. Through observation and interviews, teachers will also reflect on how well their chosen assessment techniques are working, how their work is supported and resourced, what dilemmas have arisen, how they deal with the dilemmas, and what areas need further development.

1.3 Purpose of the Study

The purpose of this study is to document, describe and determine the beliefs, practices and concerns of secondary school mathematics teachers who have chosen to implement authentic assessment practices in their classroom. Further, this study will help to determine the needs of these teachers and the conditions that support professional growth in the area of authentic assessment in mathematics.

1.4 Significance of the Study

This study provides educators such as mathematics consultants, department heads, and other mathematics educators concerned with teacher development particular insight into the concerns, beliefs and practices of teachers using authentic assessment in mathematics. It also identifies areas where teachers need support and
increased knowledge to help in their implementation of new assessment practices. As well, the study is a source of information for other mathematics teachers who are going through a similar process. Thus, the study has significant implications for those concerned with the professional development and growth of teachers in the area of assessment.

1.5 Limitations of the Study

Since the findings are based on five case studies of teachers in four different schools they are not necessarily generalizable to every teacher in every school. Because of the small sample, the study will present a window into the classrooms of those participating. Nevertheless, these findings are significant as they describe typical teachers in typical classrooms and many of their concerns will be concerns of other teachers. The case study approach gives valuable information about the details of the phenomenon of authentic assessment.

... The case study is a particularly useful methodology for exploring an area of a field of practice not well researched or conceptualized. ... Case study, which has as its purpose the description and interpretations of a unit of interest, can result in abstractions and conceptualizations of the phenomenon that will guide subsequent studies. (Merriam & Simpson, 1995, p. 112)

1.6 Researcher: Personal Background

Peshkin (1988) suggests that it is important to be aware of our subjective selves and the role that this subjective self plays in research since being aware is better than assuming we can be rid of subjectivity. Being aware of my subjective self means being aware of the qualities that enhance my research as well as the beliefs I have
about mathematics education that could skew my interpretation of the data if I were not aware of them. Eisner (1998) suggests that

Each person’s history, and hence world, is unlike anyone else’s. This means that the way in which we see and respond to a situation, and how we interpret what we see, will bear our own signature. This unique signature is not a liability but a way of providing individual insight into a situation. (p. 34)

My personal history includes over 20 years as a secondary school mathematics teacher including leadership roles of department head and assistant department head. In mathematics, what counts for me is shown through my constructivist approach, focusing on developing students’ understanding of mathematics and valuing individuality rather than relying on rote memorization of routine algorithms and only one correct answer. I have attempted to incorporate authentic assessment techniques in my own classroom. As a department head and leader, I am attentive to teacher potential and growth and demonstrate this through the presentation of collaborative workshops, encouragement of teacher portfolios and growth plans, and participant observation of my colleagues. In my attempts to incorporate new ideas in my professional practice, I often grapple with difficult issues of implementation. For instance, in attempting to encourage more problem solving in my classroom, I frequently have difficulty finding open-ended problems that will challenge rather than frustrate students. I also struggle with determining the degree to which I will intervene and prompt students’ problem solving attempts. As well, I am constantly building or revising assessment tools to match problem solving scenarios. This is further thwarted by the reluctance of many of my colleagues to join my efforts at
implementing a curriculum that incorporates problem solving, thus denying me needed support and sharing the workload. Thus, examining the practice and concern of others is of personal interest.

1.7 Plan of the thesis

The thesis is organized in six chapters as follows:

Chapter One provides an introduction to the study, as well as statements of the problem, purpose, significance, and limitations of the study. Chapter Two is a literature review of relevant research. Initially, reform in mathematics education is discussed, emphasizing the move to a problem solving model and the inherent dilemmas created for traditional assessment practices. This is followed by a discussion of the differences between traditional and authentic assessment practices, and then a focus on the role that authentic assessment plays in addressing "new" ideas about mathematics education. The discussion on authentic assessment will bring forth the importance of the teacher's role in this assessment practice. The literature review concludes with the examination of similar studies that will highlight areas demanding further exploration.

Chapter Three gives a detailed description of the method of research used in this study including the need for a qualitative approach, a description of the research setting and entry into that setting. The overall design of the inquiry will be discussed, followed by the specifics of ethical issues and how the data was collected, described, analyzed, and interpreted.
Chapter Four describes the five case studies individually, focusing on the major themes of the interviews, the in-class experiences and the teacher's reflections of those experiences as well as specific issues brought forth by the teacher. Each participant is discussed in detail with respect to several different realms. First the educational background of the participant, current teaching position, and school setting are depicted. Then the participant's view of mathematics and the role of assessment is discussed. This discussion leads into the participant's general use of authentic assessment, followed by the details of specific examples of authentic assessment activities that I have observed or the participant has described for me in interviews, or his or her assessment log book. Each participant's section will be summarized by identifying how the teacher found support for the implementation of authentic assessment as well as the dilemmas that were posed by authentic assessment.

Chapter Five presents a discussion of common elements among the five case studies, particularly focusing on issues or dilemmas that have been brought forth and how the teachers are dealing with those dilemmas. This chapter will also discuss methods, situations, resources, or attitudes that have helped the participants enhance their expertise in authentic assessment.

Chapter Six will include a discussion of key messages gained from the research, suggestions for further research and development, and a brief reflection of my work with the five participants.
Chapter Two

Review of Relevant Literature

Invariably, the field of authentic assessment in mathematics is at the intersection of several diverse areas. The review of relevant research will cover: emerging issues in mathematics education reform, the specific nature of authentic assessment, the role of the teacher in assessment, and related studies of teachers' classroom experiences with authentic assessment. I will first outline the path of the discussion before turning to each separate area.

The first area of discussion is emerging issues in mathematics education reform. I will focus on the significance of the problem solving model and I will argue that the shift to a problem solving model encourages a variety of solutions but also creates dilemmas for traditional assessment practices. The second area of discussion focuses on authentic assessment and I will consider the literature that supports authentic assessment in mathematics. In this section I will address the differences between traditional and new authentic forms of assessment, and the role that authentic assessment plays in addressing new ideas about mathematics instruction. I will also include the importance of the teacher’s role in and perspectives about authentic assessment as the teacher’s role forms the essence of my study. In the final section, I will present an extensive review of previous studies that focus on the use of authentic assessment in mathematics classrooms. This survey of related studies will
assist in establishing the framework for my work, determining areas for further inquiry and portraying issues that emerge and that demand attention.

2.1 Reform in Mathematics Education

In order to examine new techniques in mathematics assessment, it is first necessary to review the trends in mathematics education reform over the past ten to fifteen years. As previously stated, mathematics education reform grew out of an awareness that students were ill-prepared mathematically to face the twenty-first century. A Nation at Risk (NCEE, 1983) brought forward concerns about students' mathematical competence. In response to A Nation at Risk (NCEE, 1983), two schools of thought emerged. One school urged a traditional approach which suggested a focus on the acquisition of mathematics "skills" through rote memorization of algorithms that quickly brought students to an answer. The other school of thought encouraged understanding of mathematics through a constructivist approach with a focus on problem solving. The work Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) was a seminal work that set guidelines for this problem solving approach to mathematics. The new goals of mathematics education suggested:

that students should be exposed to numerous and varied interrelated experiences that encourage them to value the mathematical enterprise, to develop mathematical habits of mind, and to understand and appreciate the role of mathematics in human affairs; that they should be encouraged to explore, to guess, and even to make and correct errors so that they gain confidence in their ability to solve complex problems; that they should read, write, and discuss mathematics; and that they should conjecture, test and build arguments about a conjecture's validity. (NCTM, 1989, p. 5)
This document called for relevant mathematics to be taught in a problem solving context so that students' understanding of mathematics would increase. Instructional and assessment tasks should emphasize connections within mathematics by embedding mathematics in relevant extended contexts. There should be non-routine problems and students should learn to communicate mathematically (MSEB, 1993). Many have argued that students learn mathematics most effectively if they construct meanings for themselves.

Learning mathematics requires construction, not passive reception, and to know mathematics requires constructive work with mathematical objects in a mathematical community. (Davis, Maher & Noddings, 1990, p. 2)

Confrey (1990) suggests that

An instructor should promote and encourage the development for each individual within his/her class of a repertoire for powerful mathematical constructions for posing, constructing, exploring, solving and justifying mathematical problems and concepts and should seek to develop in students the capacity to reflect on and evaluate the quality of their constructions. (p. 112)

In the case of young children, evidence supports that students have an intuitive and informal sense of mathematics and that formal mathematics education should build upon these informal understandings of mathematical concepts (Groen & Resnick, 1977; Hughes, 1981; Wood & Sellers, 1997). Teachers are encouraged to create classrooms where students are engaged in active problem solving situations that encourage reflective thinking.

Much of the current reform effort in mathematics education is directed at providing curriculum and pedagogical support for students as they engage in mathematical thinking and problem solving. (Silver, 1989, p. 280)
Thus, it is essential to understand what is meant by this new problem solving approach.

The issue of problem solving merits particular attention as current research suggests that mathematics should be learned within a problem solving context where students are conjecturing, abstracting, explaining their reasoning, testing their conjectures and communicating, discussing and questioning their own thinking and the thinking of others (MSEB, 1989; NCTM, 1989; Lesh, Lamon, Behr & Lester, 1992).

The NCTM defines problem solving in the following way:

Mathematical problem solving, in its broadest sense, is nearly synonymous with doing mathematics. Thus, whereas it is useful to differentiate among conceptual, procedural, and problem solving goals for students in the early stages of mathematical learning, these distinctions should begin to blur as students mature mathematically. In grades 9-12, the problem solving strategies learned in earlier grades should have become increasingly internalized and integrated to form a broad basis for the student’s approach to doing mathematics, regardless of the topic at hand. From this perspective, problem solving is much more than applying specific techniques to the solution of classes of word problems. It is a process by which the fabric of mathematics as identified in later standards is both constructed and reinforced. (NCTM, 1989, p. 137)

Problem solving places an emphasis on students “understanding mathematics.” The reform in mathematics education rests on the belief that understanding mathematics is more valuable than memorizing algorithms. Studies support the claim that the solution of open ended problems increases understanding and makes use of the higher order thinking skills (Romberg, Zarinnia & Collis, 1990). Wood and Sellers (1997) indicate that students from problem-centered mathematics classrooms have a better understanding of mathematics and hold different beliefs about mathematics. These students believe that being able to explain mathematics is a
component of being successful in mathematics and that finding and using different ways to solve problems has great value. Students’ beliefs about mathematics and their attitudes toward mathematics also affect their understanding. Furthermore, metacognition affects mathematics problem solving (Brown & Baird, 1993; Schoenfeld, 1992). Schoenfeld (1987) suggests that students require three categories of knowledge and behaviour for problem solving. First, resources, such as mathematical facts and algorithms, are required. Students must have a repertoire of mathematical skills and knowledge to apply to a problem solving situation. Second, the students must have the control to select and implement the available resources. Students need control of the problem solving situation. They need to be free to make decisions as to the method of solution of the problem or the organizational structure they may use to develop a solution (such as tables, charts, or graphs). And third, the student’s belief system, mathematical world view, and attitude or approach to mathematics affects the solution of problems. The confidence level of the student and the ability to take risks may affect the students engagement in and solution of the problem.

While recognizing that good problem solving settings are valuable, creating problem solving situations to increase mathematical understanding is a difficult and complex task. Some suggested open-ended problem scenarios could include: designing a parking lot for a shopping mall, creating containers to maintain volume and reduce surface area, generating and piecing together equations to model the curves of a sports car to use in a Computer Aided Design, or researching and presenting new ways to prove a traditional theorem. These suggestions would
naturally require further design to emphasize that there may be more than one solution and that each solution rests on different assumptions and beliefs, technical knowledge, divergent thinking and active learning. The student will be using mathematical skills and algorithms applied through flexible generalizations, active learning, discussion, conjecturing and modeling (Ginsberg, Lopez, Mukhopadhyay, Yamamoto, Willis & Kelly, 1992). These types of situations also require that students make connections between their informal or intuitive knowledge and formal knowledge, and consequently are often presented at the concrete level, possibly with the use of manipulatives or "hands-on" materials to help to bridge the gap between informal and formal thinking. (Franke & Carey, 1997; NCTM, 1989)

The teacher's role in creating a problem solving environment is an important one. The teacher must be aware of Schoenfeld's three categories of knowledge and behaviour so that the teacher can provide the necessary instruction and resources to tackle complex problems. Creating this type of problem solving environment requires careful planning and a willingness on the teacher's part to accept the challenge that this environment creates. Problem solving moves away from the structured path of following algorithms to a process involving constructing, describing, manipulating and predicting (Lesh et al., 1992).

A classroom environment where exploration is encouraged and where perseverance is rewarded is likely to help students become good problem solvers. With encouragement and specific feedback from teachers, students can learn to monitor themselves as they struggle with complex problems. The teacher can model questioning and promote suggestions from students, while making it clear that ultimately problem solutions must meet certain mathematical standards. (NCTM, 1998, p. 313)
Teachers must provide students with the necessary tools to solve problems but must also value the students' true creation of a viable solution. Teachers need to acknowledge that a true problem could have many solutions and thus there are many different perspectives on the problem. As well, the posing of the problem is extremely important as problems can be presented in many different ways. Frequently the presentation of the problem eminently structures the levels of problem solving (Goldin, 1992). For instance, teachers could feel that they are being helpful by suggesting a strategy to solve the problem or by giving a chart for students to organize information. By so doing, the teacher may be taking away the true problem solving experience of brainstorming to seek out methods to begin to understand the problem. Stiggins and Conklin (1998) suggest that

We must therefore strike a delicate balance as teachers between respecting our students and challenging their thinking and beliefs. We must provide them with useful knowledge but also alert them to problems in their thinking. Thus, teaching for understanding means more than designing opportunities to learn. It also means teaching in ways that challenge resistance to new ideas. (p. 173)

The role of the teacher is extremely significant as the teacher needs to create rich learning tasks and also should gauge how much assistance should be given so that the experience is rewarding for the student. The teacher must recognize the subtle difference between frustrating or challenging the student and pose problems accordingly.

This notion implies a view of mathematics classrooms as places where students, under the careful tutelage of their mathematics teachers, engage in doing mathematics rather than having it done to them. A view of mathematics classrooms as environments for collaborative practice in doing mathematics assumes not only that teachers will be skillful in orchestrating the dynamics of such classrooms but also that
they will be able to play the role of master mathematical thinker for the apprentice students. Certainly both of these assumptions need to be tested, and the testing of these assumptions suggests many additional items for a research agenda. (Silver, 1989, p. 280)

Thus, a challenge for mathematics teachers is to create a problem solving environment, and consequently, to assess students' understanding of mathematics in this environment. Consequently, mathematics educators must examine the assessment techniques that are being used to evaluate students' mathematical understanding as well as the issues faced when implementing such techniques.

2.2 Authentic Assessment

The previous section on mathematics education reform suggests that instructional practices must change to facilitate the development of students' understanding of mathematics. Assessment strategies must coincide with instructional techniques and thus it is necessary to explore ways of assessing a problem solving approach. Badger, Cooney, and Kanold (1993) suggest that:

Given the current emphasis on evaluation, it is important that both teachers and researchers focus on how we can better assess our students' understanding of mathematics. What is needed are means by which researchers and teachers can come to understand the issues each group faces so that we can all become more fully informed about evaluating students' understanding of mathematics. (p. 273)

Authentic assessment is seen as a viable solution to address the need to match assessment with instruction.

The following discussion on authentic assessment is divided into three main components. The first component is a general discussion of authentic assessment which includes definitions, examples, and a review of advocacy literature. The
second component considers issues that emerge when authentic assessment is implemented. This focuses on issues of accountability and consequently, on the importance of the role of the teacher in authentic assessment. The third component is a review of recent studies that have examined the practice of authentic assessment in mathematics classrooms. The entire section on authentic assessment will conclude with an emphasis on the outstanding issues that still must be addressed. The issues to be explored by my study will be summarized.

2.2.1 General Discussion on Authentic Assessment

It is apparent that new assessment techniques are required to assess understanding of mathematics concepts. Assessing a student's understanding of mathematics through problem solving requires different forms of assessment because standard paper and pencil tests do not necessarily provide evaluators with information concerning strategies students use to solve problems. With traditional tests, it is often only the answer that counts as well as perhaps recognizing a suitable algorithm to reach the answer. Teachers need assessment strategies that encourage risk-taking, allow for mathematical communication, and demonstrate the application of knowledge to unfamiliar settings. Stiggins and Conklin (1992) claim that

... Concern for accountability has given rise to innovative thinking about alternative forms of assessment. New forms of paper and pencil and performance assessment are emerging. This will provide for the proper translation of a broader array of valued outcomes into sound assessment. (p. 3)
Assessment techniques must also provide students with a forum to enhance their metacognitive skills and to develop positive attitudes towards the challenge of solving mathematical problems.

New assessment techniques have many different names: alternative assessment, performance assessment, holistic assessment, outcome-based assessment and authentic assessment. Hart (1994) defines authentic assessment:

An assessment is authentic when it involves students in tasks that are worthwhile, significant, and meaningful. Such assessments look and feel like learning activities, not traditional tests. They involve higher-order thinking skills and the coordination of a broad range of knowledge. They communicate to students what it means to do their work well by making explicit the standards by which that work will be judged. In this sense authentic assessments are standard-setting, rather than standardized, assessment tools. (p. 9)

Authentic assessment employs a variety of strategies. These include self and peer assessment, observation, group problem solving tasks, presentations, holistic scoring or portfolio assessment. Each of these strategies can be accompanied by several different assessment tools such as rubrics or checklists. I would like to take a moment to clarify and define some of these terms, as they will be used throughout the thesis: rubric, performance assessment, and portfolio. A rubric is a form of checklist or chart with the outcomes listed down one side of the page and the levels of performance (usually four or five) listed across the top. Usually each level of performance has a descriptor (or criteria) for that level of achievement for that particular outcomes (Hart, 1994). Performance assessment is

Direct, systematic observation and assessment based on student performances or performance samples and established performance criteria. (Hart, 1994, p. 111)
A portfolio is a systematic, organized collection of student work and student reflections that demonstrates the growth of the student's knowledge, skills, and attitudes (Vavrus, 1990). The student participates in the selection of portfolio content as well as in determining the criteria for selection and judging merit (Arter & Spandel, 1992). Generally, the strategies of authentic assessment document learning over time rather than a single summative event.

As with the differences between traditional and problem solving approaches to mathematics instruction, differences between traditional evaluation and performance assessment arise from the underlying assumptions about the nature and purpose of mathematics instruction. A traditional approach views instruction as a demonstration of finished behavior and humans as information processors.

A narrow focus on technical criteria - primarily reliability worked against good assessment. For too long, reliability meant that examinations composed of a small number of complex problems were devalued in favor of tests made up of many short items. Students were asked to perform large numbers of smaller tasks, each eliciting information on one facet of their understanding, rather than to engage in complex problem solving or modeling, the mathematics that is most important. . . . Today we recognize that students must learn to reason, create models, prove theorems, and argue points of view. You cannot get at this kind of deep understanding and use of mathematics by examining little pieces of learning. Assessments that are appropriately rich in breadth and depth provide opportunities for students to demonstrate their deep mathematical understanding. (MSEB, 1993, pp. 4, 5)

The performance assessment model sees mathematics as an activity and humans as model builders who construct, differentiate, refine and extend different models. Authentic assessment allows students the opportunity to demonstrate what they
know and can do. The NCTM Assessment Standards for School Mathematics (1995) suggests:

At present, a new approach to assessment is evolving in many schools and classrooms. Instead of assuming that the purpose of assessment is to rank students on a particular trait, the new approach assumes that high public expectations can be set that every student can strive for and achieve, that different performances can and will meet agreed-on expectations, and that teachers can be fair and consistent judges of diverse student performances. Setting high expectations and striving to achieve them are quite different from comparing students with one another and indicating where each student ranks. (p. 1)

Other differences also appear. For a traditionalist, assessment is separate from instruction and is usually a high pressure event (Lesh & Lamon, 1992). As well, students feel isolated in the assessment process as Anderson (1993) describes below:

When assessment is perceived exclusively as the teacher's domain, students willingly wait for the teacher to judge their success or failure. When the emphasis seems to be on external judgment, learners assume that they cannot and should not be decision makers. Assessment exclusively by one judge leads children to forfeit their autonomy and self-validation. (p. 103)

However, in authentic assessment, instruction and assessment are integrated and progress is monitored on a consistent basis over time.

Assessment should be an integral part of teaching. It is the mechanism whereby teachers can learn how students think about mathematics as well as what students are able to accomplish. (MSEB, 1989, p. 69)

Performance assessment also acknowledges that students have different learning styles and many ways of demonstrating their mathematical ability.

If students demonstrate their mathematical power through a multiplicity of behaviors - being able to ask important questions, to make connections, to apply understandings to novel situations, and to do so confidently and efficiently - then teachers must also use a variety of methods for assessment. (Webb & Coxford, 1993, p. 10)
These forms of assessment acknowledge that teachers, students and parents are the stakeholders. Whereas traditional assessment often minimized cost and time commitments through controlled time and quantitative scoring methods, performance assessment takes a great deal of time, for the teacher is verifying levels of achieved patterns of behaviour often throughout a variety of activities.

The responsibility for describing profiles and conditions for assessing students must fall mainly to the teachers as they are normally closest to the students. They are also capable of observation over long periods of time and in diverse kinds of learning and problem solving situations. (Lesh et al., 1992, p. 407)

Authentic assessment techniques are being chosen for implementation in a variety of mathematics classrooms because of the belief that assessment should reflect the mathematics that is important for students to learn and the instructional techniques that are used in the classroom. New assessment strategies should reflect new decision making issues, new sources of assessment information, new understandings about the nature of mathematics, mathematics instruction and mathematics learning and problem solving.

The use of problem solving activities reveals the mathematics the students choose to use rather than the mathematics they can demonstrate on request. This distinction is crucial and represents a new recognition of the extent to which our past assessment strategies have misled us by focusing on explicitly cued facts and procedures. (Clarke, 1992, p. 13)

There is also a distinct shift in the criteria for judging the quality of assessment instruments. In order to examine assessment techniques, it is first necessary to determine what is being assessed. Teachers need to understand the outcomes of instruction and then to determine what, why and how various assessment tools will
address these outcomes. A broad range of assessment techniques need to be employed (Wiggins, 1989). The assessment framework must be much more than a collection of routine or non-routine problems. It must be based on independent characteristics of what is to be assessed, and should be descriptive, indicating what students can and cannot do. Assessment also needs to be reflective so that students can grapple with mathematical discovery and reflect on their grappling. As Clarke (1992) points out:

> Effective assessment is a continuous process predicated on the teacher's and the student's mutual recognition of the goals of the learning experience and the criteria for success. (p. 12)

Assessment is best when it contains a variety of methods for assessing key cognitive components. Some suggestions are structured interviews, concrete models, group problem solving, creative projects, portfolio evaluations and paper and pencil tests (Goldin, 1992; Clarke, 1992; Hart, 1994). Performance assessment includes open-ended problems, scoring rubrics, student self-assessment and student journals. Mathematics portfolios are often used as an assessment tool. As Lambdin and Walker (1994) describe their experience with the use of portfolios in mathematics class:

> My students are more thoughtful about what mathematics they are studying and why. They seem to be developing a better understanding of what is meant by problem solving and mathematical reasoning, less often resorting to the blind application of computational algorithms when confronted with problems. (p. 100)

These portfolios include student work, projects, notes, photographs, or models, chosen by the student because they demonstrate the achievement of relevant
outcornes. Generally a reflection sheet accompanies each piece of mathematical work and this helps to develop metacognitive skills and assess learning over time.

Maher, Davis and Alston (1992) note that when teachers uses a wide variety of these authentic assessment techniques, they gain a window into the student's thinking and understanding of mathematics and encourage students to describe their own problem solving strategies. Wiggins and McTighe (1998) state that

When we speak of evidence of understanding, we are referring to evidence gathered through a wide variety of formal and informal assessments during a unit of study or a course. We are not alluding only to end-of-teaching tests or culminating performance tasks. Rather, the collected evidence we seek may well include observations and dialogues, traditional quizzes and tests, performance tasks and projects, as well as students' self assessments gathered over time. (p. 13)

Students also gain insight into their own understanding of mathematics when problem solving strategies are shared through group problem solving and peer assessment. Thus, students gain exposure to other strategies and perspectives which they can then incorporate into their own problem solving repertoire. Thought processes are revealed when students have a chance to write or talk about them.

In the thinking curriculum, thinking pervades the classroom and is thus relatively easy to access. (Ginsberg et al., 1992, p. 287)

When a teacher focuses on mathematics as thinking then they must also encourage a discussion of procedures, self-examination and reflections and making mathematical thought public. A teacher encourages and gives value to this type of mathematical thought when assessment strategies address these processes and allow students to communicate their thinking.
2.1.2 Issues that Emerge with Authentic Assessment

There are two key issues that emerge when authentic assessment is adopted. The first is the issue of accountability and the second is the importance of the role of the teacher in assessment. These two issues are intrinsically linked because the reliability and validity of authentic assessment is largely dependent on the teacher's role in the process of authentic assessment.

2.1.2.1 Reliability and validity of authentic assessment

In many cases, parents and students may be very trusting of a mark from a traditional test but uncomfortable with an assessment using observation, performance scales, or other authentic assessment tools, even though the authentic assessment may be looking at issues of deeper understanding of mathematics learning rather than the memorization of algorithms. There are questions of fairness, objectivity and precision; especially when innovative types of assessment are used over traditional assessment. Lesh and Lamon (1992) suggest that:

To improve assessment, two distinct approaches can be taken: one involves improving the content quality of standardized tests by focusing on authentic mathematical abilities that are productive in realistic situations. The other involves improving the credibility, reliability, and fairness of alternative forms of assessment including teachers' classroom observations, and students' extended projects. Improvements in teacher education are obviously critical to the second approach, but for the first, it is also necessary for teachers to assume greater responsibility in the assessment process. (p. 406)

For these reasons, it is necessary to define the characteristics of good authentic assessment techniques and many have sought to do this. Lesh and Lamon (1992) state that concepts of reliability and validity need to be redefined when authentic
assessment is considered. Much of the current assessment literature is attempting to define characteristics of validity and reliability in authentic assessment. *Measuring What Counts* (MSEB, 1993) suggests that the new assessment should be judged using three criteria: the content principle, the learning principle, and the equity principle.

Whether a mathematics assessment comprises a system of examinations or only a single task, it should be evaluated against the educational principles of content, learning, and equity. At first glance, these educational principles may seem at odds with traditional technical and practical principles that have been used to evaluate the merits of tests and other assessments. In recent years, however, the measurement community has been moving toward a view of assessment that is not antithetical to the positions espoused in this volume. Rather than view the principles of content, learning, and equity as a radical break from past psychometric tradition, it is more accurate to view them as gradually evolving from earlier ideas. (MSEB, 1993, p. 117)

Lesh and Lamon (1992) suggest that new assessment should include authentic mathematics, realistic problems, and assess genuine mathematical abilities. *The Assessment Standards for School Mathematics* (NCTM, 1995) suggests that there are six standards for assessment:

**The Mathematics Standard**: Assessment should reflect the mathematics that all students need to know and be able to do. (p. 11)

**The Learning Standard**: Assessment should enhance mathematics learning. (p. 13)

**The Equity Standard**: Assessment should promote equity. (p. 15)

**The Openness Standard**: Assessment should be an open process. (p. 17)

**The Inferences Standard**: Assessment should promote valid inferences about mathematics learning. (p. 19)

**The Coherence Standard**: Assessment should be a coherent process. (p. 21)
For authentic assessment to be accountable, educators need to be able to specify what is being assessed and how it is being assessed. Adams (1994) suggests that in planning for mathematical assessment, there are several theoretical and practical problems of which mathematics teachers must be aware. These include the scope and assessment of concepts and higher order thinking skills plus the necessity to align assessment and instruction.

Kulm (1990) states that what is important is that we are able to construct frameworks, specifications and descriptions for necessary mathematical skills, processes, content, abilities and performances. He continues by saying that:

We need to be able to define and categorize fundamental higher order thinking processes in mathematics, as well as other important processes that have specific applications in mathematical contexts . . . We need to be able to specify the math thinking processes and abilities expected of students at key points in their mathematical development and education. (Kulm, 1990, p. 3)

As well as being able to adequately describe what is expected of students at key points in their mathematical development, reliability and validity can be improved by increasing teachers' expertise in authentic assessment instruments. Stiggins and Conklin (1992) claim that

The optimist says assessment will drive instruction in the future and new and better assessments are being developed to do the job. But the cautious optimist says this will only happen if educators at all levels understand the difference between sound and unsound assessment and can integrate sound assessment into the instruction process in effective ways. (p. 3)
As teachers become more adept at employing authentic assessment methods, issues of accountability will lessen. The role of the teacher in authentic assessment is therefore seen as crucial, and will be explored in the next section.

2.1.2.2 The Teacher's Role in Assessment

The accountability of authentic assessment largely rests on the teacher. Teachers need to be well-versed in authentic assessment because much of the validity and reliability of the assessment tools rest in the expertise of the teacher.

We would be wise to consider the question of what meanings teachers ascribe to evaluation, and how the above questions are answered in the crucible of the classroom. For it is in the classroom that evaluation takes place, and it ultimately is there that the issues must be resolved. (Badger et al., 1993, p. 273)

The teacher's role in authentic assessment is extremely important because teachers are the best assessors of students as they are normally closest to the students and are in a situation to observe students over long periods of time and in diverse kinds of learning and problem solving situations (Lesh et al., 1992).

Indeed, teachers should be the primary conductors of assessments. Most assessments conducted by school psychologists, evaluators, and administrators provide little information of any value to classroom teachers. (Ginsberg et al., 1992, p. 287)

The teacher can be viewed as a cognitive coach, studying the performance of students and trying to improve their performance. Teachers have a great responsibility to describe profiles of student behaviours, skills and achievement, assisting students in recognizing successes and weaknesses, and working with students to make improvements (Maher et al., 1992).
Much of the information needs to be derived by teachers during the process of instruction. Teachers are the persons who are in the best position to judge the development of students' progress and, hence, must be considered the primary assessors of students. (NCTM, 1995, p. 1)

The assessment of problem solving through authentic assessment allows teachers to determine the methods that students use to solve problems. As well, teachers gain insight into the different thinking processes that students use in learning classroom mathematics (Ginsberg et al., 1992). From a diagnostic perspective, teachers also identify the concepts and misunderstandings that are underlying students' work (Brown & Baird, 1993).

Assessment of thinking can only occur in classrooms where thinking is encouraged. The traditional teacher who instructs students in standard algorithms and attends to correct versus incorrect answers is in a weak position to assess understanding. In contrast, teachers who encourage students to engage in mathematical activities, to develop their own method of solution, to discuss mathematical ideas and procedures and to believe that each individual approach to a problem has value are in a better position to learn about and assess a student's understanding (Ginsberg et al., 1992).

2.1.2.3 Teachers' Knowledge and Beliefs

Teachers' pedagogical knowledge, content knowledge, and beliefs and attitudes about mathematics can affect activities in the classroom (Kulm, 1994). When authentic assessment is used, teachers' knowledge, beliefs and attitudes toward mathematics affect how they assess students' understanding. As teachers play an
increasingly significant role in the assessment process, it is important to examine the knowledge, beliefs, and attitudes that they bring to this process.

Knowledge of mathematics is crucial. Several studies indicate that how one teaches a subject is greatly influenced by the ways that the teacher understands the subject (Grossman, 1992; Thompson & Thompson, 1996; Roulet, 1998; Goldin, 1992). Goldin (1992) suggests that

What a teacher thinks mathematics is may greatly affect his or her approach to it in the classroom. Is it a body of absolute truth, or a set of arbitrary conventions? Is mathematics discovered or invented? Is it a set of rules and structures that exist apart from the individual or does each person have his or her own set? What is the relation between mathematics and experience with non-mathematical entities, such as physical objects? (p. 44)

Roulet (1998) describes the impact of one of his participant's mathematical knowledge on practice:

Jonathan's strong conception of mathematics provides him with a solid base for personally arguing for his classroom use of group work, student discussions, inductive reasoning from patterns, collaborative problem solving, and open-ended creative investigations. In the interview and discussions exploring the reasons for his pedagogical choices, Jonathan linked his decisions back to his image of mathematics. (p. 216)

Shulman's (1988) studies from Stanford show that teachers with greater mathematical knowledge were more open, exploratory, and conceptual in their teaching; while teachers with lower levels of knowledge were more rule based. Moreover, Shulman's (1986a,b, 1988) studies show that teachers with more mathematical knowledge could more easily detect students' misconceptions and could recognize students' insightful comments. Teachers with less knowledge may feel threatened by students' questions or the teacher may not be able to pick up on student suggestions that represent
different but equally valid ways of thinking about a mathematical concept or developing a solution to a problem. Brown and Baird (1993) suggest that:

There is still very little research that looks in depth at what teachers understand about mathematics. Yet the mathematics taught in secondary schools is quite complex mathematical ideas, facts and concepts, and the relationships between and among them, must be taught, but the teacher must also be concerned with the processes of doing and creating mathematics. Clearly, teachers must know mathematics well in order to teach it. (p. 247)

Steffe (1990) concurs:

Improving mathematical education in the schools starts with improvements in the mathematical knowledge of teachers. (p. 184)

Teachers also need pedagogical knowledge about students' understanding of mathematics. Teachers need to comprehend what students are doing to successfully guide the students and often this information is difficult for the teacher to collect or recognize (Maher et al., 1992). Teachers need insight into the thinking processes of mathematics in order to assess the thinking of their students. Furthermore, teachers' assumptions about what students are doing are not necessarily true.

The teacher's realization that the student may be thinking about a situation differently than the teacher expects is a powerful one. (Maher et al., 1992, p. 259)

Assessing problem solving presents particular problems since evaluators and teachers must obtain information concerning students' thinking activities as well as assessing students' understanding and procedural and conceptual difficulties (Ginsberg et al., 1992).

As well as content knowledge and pedagogical knowledge, teachers views, beliefs and attitudes about mathematics influence their instructional practices.
Teachers' theories and belief systems influence their perceptions, plans and actions in the classroom (Carpenter & Fennema, 1991). Thompson and Thompson (1996) state that:

> It is that teachers' images - the loose ensemble of actions, operations, and ways of thinking that come to mind unawarely - of what they wish students to learn, and the language in which they have captured those images, play important roles in what teachers do, what they teach, and how they influence students' understandings. (p. 19)

Correspondingly, teachers' confidence with mathematics affects the way they handle problem solving in their classroom and further research suggests that teachers' beliefs about mathematics and how it should be taught do indeed influence the way that they teach their subject (Brown & Baird, 1993). Naturally, teachers also can have a positive effect on their students' beliefs, attitudes and understanding. Thus, teachers need to recognize their own influence on learning and to monitor their own knowledge, beliefs and attitudes in order to ascertain how they may influence thinking and action in classrooms. Simon and Tzur (1999) recognize that teacher development often enhances teachers' knowledge in several ways:

Teacher development, particularly in the transition from traditional teaching toward practice consistent with current reform principles, requires teachers to develop their knowledge in a variety of areas (e.g., mathematical knowledge, understanding of children's thinking, conceptions of the role of the teacher). Furthermore, the growth in one area is often dependent on growth in other areas. For example, growth in teachers' understanding of how students develop concepts of fractions may be limited by their own understanding of the mathematical concepts and by their understanding of what it means to understand and do mathematics. (p. 263)

Although there is a need to supplement our current system of tests with better alternatives, it is just as significant to develop teachers' expertise with these better
alternatives. Teachers' responses to students' questions and problem solving endeavours reflect their knowledge but they also reflect their beliefs and attitudes about mathematics. A study by Haines (1996) recognized that although a teacher may have the best intentions to use a "reformed" curriculum, the knowledge and beliefs that the teacher currently holds tend to be a great influence on teaching practice.

Despite the intention that there should be a de-emphasis on algorithms and techniques in the new curriculum, algebraic manipulation remained prominent. (Haines, 1996, p. 599)

In focusing on secondary school mathematics, Brown & Baird (1993) suggest that:

From what little research we have on secondary mathematics teachers there is some evidence that teachers' responses to these dilemmas are at least partially based on their knowledge, beliefs, and attitudes related to mathematics, student learning, and teaching. They draw on these to help them make decisions on what action to take in the classroom. Teachers' decisions and actions then influence students' knowledge, beliefs and attitudes, both about mathematics and about the learning and teaching of it. (p. 240)

However, assessment of a student's understanding of mathematics is fundamentally a qualitative judgment based on long-term, personal interaction best accomplished by individual teachers. The reform of assessment requires much more than the creation of new instruments. A system is required to measure understanding descriptively and also to develop teachers' understanding of mathematical problem solving and how beliefs and attitudes influence this understanding. Parents, teachers, administrators and students need an understanding of mathematical content and processes as well as how these new methods of assessment are intended to assess these processes. Changes are necessary in the outcomes of instruction, the preparation of teachers and the assessment techniques themselves (Goldin, 1992).
2.3 Similar Studies

This section will review studies that examine the implementation of authentic assessment in classrooms. These studies have similarities with one another and with my study. Since authentic assessment in mathematics is relatively new, most of these studies have taken place during the past five years. Studies of both elementary and secondary school mathematics classrooms are included, as research on solely secondary school mathematics classrooms is sparse and the examination of the design of the elementary studies is useful. Initially, studies that concern the impact of authentic assessment in classrooms will be reviewed. Subsequently, studies that specifically address the experiences of teachers through the process of implementing authentic assessment will be considered.

Much of the work that has been done in classrooms on authentic assessment has focused on how the use of authentic assessment affects activities within teachers' classrooms (Kulm, 1994; Flexer, 1995; Borko, 1997; Haines & Izard, 1994). This is true of both large-scale assessment projects and individual single classroom changes in assessment. It has also been true of both elementary and secondary classroom settings, although the majority of the research has been in the elementary school. Several studies emerged from a University of Colorado Assessment Project with third grade classrooms (Shepard, 1994; Flexer, 1995; Borko, 1997). One study was based on the observation of third grade classrooms, the other on interviews with students, and the third on the work and role of teachers (Shepard, 1994). Flexer's (1995) study reported on fourteen third grade teachers who introduced performance assessments.
in the hope of improving both instruction and assessment in mathematics. The main finding in Flexer's (1995) study was that teachers adopted many changes with respect to course content, pedagogy and assessment. In Flexer's (1995) study, it was noted that, by the end of the project, many teachers were using more hands-on and problem based activities that were closely aligned with the NCTM standards. As well, the introduction of performance assessment raised teachers' expectations of what their students could accomplish.

Kulm's (1994) study of the implementation of authentic assessment in both elementary and secondary mathematics classrooms investigated whether the use of alternative assessment has an effect on classroom instruction and on students' attitudes toward mathematics. By examining the effects of alternative assessment on activities within teachers' classrooms, he noted that, over the period of the project, teachers increased their use of activities aimed at meaning and understanding (Kulm, 1994). When teachers used alternative teaching techniques, there was a change in instructional strategies which included more group work and the use of computers and calculators. There was also an increase in higher-order thinking strategies and an improvement in students' attitudes toward mathematics.

These changes were noted in other studies as well (Mitchell, 1992; Ryan, 1994). Mitchell (1992) recognized that there was an emphasis on conceptual and contextualized knowledge. Ryan’s (1994) study of third grade classrooms in California reported that teachers often re-sequenced curriculum, introduced new content, and emphasized educational processes more than they did before the new
assessments were introduced. In examining the impact of large scale reform in mathematics assessment in Australia, Morony and Olssen (1994) noted that the implementation of authentic assessment caused significant improvement, in some cases, in the teaching and learning of mathematics. Morony and Olssen (1994) suggested that the attention to and legitimization of informal assessment practices could improve the teaching and learning of mathematics in Australian schools.

The introduction of the Mathematics Profile, linked as it is to calls for accountability while at the same time relying on teachers' professional judgment, will cause teachers to consider a review of their assessment practices. (Morony & Olssen, 1994, p. 398)

In several studies, new assessment practices created new instructional practices (Kulm, 1994; Mitchell, 1992; Ryan, 1994; Flexer, 1995; Morony & Olssen, 1994).

We wanted to see if and how alternative assessment changed what teachers did in the classroom . . . We found that when teachers used alternative approaches to assessment, they also changed their teaching. Teachers increased their use of strategies that research has found to promote students' higher-order thinking. They did activities that enhanced meaning and understanding, developed student autonomy and independence, and helped students learn problem solving strategies. (Kulm, 1994, p. 175)

In other studies, new instructional practices necessitated new assessment practices. Lehman (1995) worked with a secondary school mathematics teacher who attempted to use more co-operative learning strategies in his mathematics classroom and recognized that new assessment strategies came about because of the change in instruction. The result was that the teacher faced the new problem of assessing the new type of learning that was now occurring.
Several of the studies mentioned above noted differences in the degree to which new assessment strategies affected change in instruction. There were varying plans and implementation strategies according to grade level, especially when elementary school was compared to high school (Kulm, 1994). Many of the studies were done in elementary classrooms, particularly grade three (Ryan, 1994; Flexer, 1994; Borko, 1997). However, in studies that included both elementary and secondary school classrooms there were distinct differences between the two (Kulm, 1994; Morony & Olssen, 1994). In the Morony and Olssen study (1994), it was found that

Primary teachers in the study tended to value informal assessment more than secondary teachers in that these practices were reflected in their reporting of student achievement in mathematics. Overwhelmingly, secondary teachers relied on formal assessment methods when reporting student achievement. (p. 392)

In Kulm’s study (1994), it was noted that although the high school student group seemed more resistant to change, they also showed the greatest increase in attitude scores as the project progressed. Student questionnaires showed that authentic assessment contributed to positive attitudes toward mathematics, especially among female students. Other differences were noted among teachers. For instance, differences in outcomes were noted which depended on the length of time the teacher had been teaching, the grade level being taught and the teacher’s prior experience with authentic assessment (Kulm, 1994). Morony and Olssen (1994) noted that the potential to impact on instructional practice was realized to different extents. For some teachers, the new assessment techniques represented a substantial challenge while others claimed that it confirmed approaches that they had already started
(Morony & Olssen, 1994). Tanner and Jones (1994) noted that the role of the teacher was pivotal in authentic assessment. The importance of, and differences between, teachers' experiences through the implementation of authentic assessment is an important issue and warrants further exploration.

A few of the studies specifically address the teachers' experiences through the implementation of authentic assessment (Rowley, Brew & Ryan, 1996; Borko, 1997; Morony & Olssen, 1994). Rowley, Brew and Ryan (1996) used qualitative data to provide insights into experiences of teachers involved in the implementation of new curriculum. Thirty-seven Year 12 (grade 12) teachers were each given a one hour interview. There were many common themes that appeared in the data: professional practice, curriculum, choice, external influences, gender issues, ESL student issues, assessment, workload, and student learning. The research team focused on the themes of "professional practice, curriculum and choice". They examined how teachers have changed the way they teach mathematics as a result of the curriculum innovation and noted that more than half had changed their instructional techniques to be more problem solving oriented and this was viewed positively by the teachers.

The most important finding from this work is that teachers are convinced that their classroom practice has changed, and has changed for the better. (Rowley, Brew, Leder, Ryan, Monash & LaTrobe Universities, 1996, p. 7)

Teachers also reported that they had problems balancing "covering the content" with problem solving tasks. They felt pressure from two sides, one side urging them to do more traditional work and the other urging them to do more innovative work. These teachers also reported an increased workload.
Many studies reported that teachers changed through the implementation process. Flexer (1995) reports that teachers changed throughout the implementation process rather than immediately changing their behaviour at the initial mandated change. Rowley, Brew, and Ryan (1996) noted that some teachers reported that they needed to be forced to change whereas others maintained their traditional course throughout the innovations and were highly critical of the reform. In examining teachers' experiences through the implementation process, Kulm (1994) examined the interplay between teachers' knowledge, new knowledge about alternative assessment and resulting classroom teaching processes. As Kulm (1994) suggests:

... Knowledge about alternative assessment strategies acts to enrich teachers' knowledge of learners' cognitions. Teachers learn about their students' mathematical knowledge, understanding, and problem solving processes. ... This enriched and in-depth understanding about students has an impact on teachers' pedagogy. Teaching strategies that were dormant or not well developed become activated and intensified. More traditional teacher-centered approaches are used less often in light of evaluations of their effectiveness in meeting students' cognitive needs. In some instances, knowledge of alternative assessment may also act upon and extend teachers' mathematical knowledge through work in developing tasks and measuring students' mathematical performances. (p. 167)

Teacher support through the implementation process was also examined. It was recognized that teachers need to be supported and provided with opportunities to discuss and debate issues (Morony & Olssen, 1994; Rowley, Leder & Brew, 1994; Rowley, Brew, Leder, Ryan, Monash, & LaTrobe Universities, 1996).

Innovation without professional development support is usually seen as a recipe for failure. ... Professional development does not just occur in response to attendance at courses and conferences; in fact many would argue that the best professional development occurs in informal settings. We found encouraging evidence that the process of change has fostered greater communication among mathematics teachers, and that this has
been a powerful source of support. (Rowley, Brew, Leder, Ryan, Monash, & LaTrobe Universities, 1996, p. 6)

Rowley’s conclusions that the best professional development occurred in informal settings is supported by others. Morony and Olssen (1994) suggest that this informal discussion helps teachers to construct their own meaning in terms of day-to-day teaching. The accountability of authentic assessment rests with teachers, and trusting teachers judgment must be more than rhetoric (Morony & Olssen, 1994). Support for the important role that teachers play in authentic assessment is vital (Morony & Olssen, 1994). Kulm’s (1994) study showed that in-service programs on alternative assessment paid dividends in helping mathematics teachers use approaches to enhance higher-order thinking processes.

2.4 Summary

Previous studies have addressed several issues concerning authentic assessment. In summary, I will state what these studies have accomplished, what areas still remain to be explored, and the areas that my study will probe. Later, in the section on method, I will discuss how I organized my exploration.

Many of the studies on authentic assessment have been done in elementary school classrooms. Thus, research related to secondary school mathematics teachers is very limited (Brown & Baird, 1993). Although we can learn from the experiences of elementary school teachers, it was noted that the experiences of elementary and secondary school teachers appears to be different (Kulm, 1994). My study will specifically examine the practices of secondary school teachers and will therefore help
to fill in the gap in knowledge of authentic assessment in secondary school mathematics classrooms.

Many of the previous studies focus on how authentic assessment affects instruction rather than describing teachers' experiences with authentic assessment. Furthermore, of the studies that specifically address teachers' experiences with authentic assessment, there are few with secondary school teachers. In my study I will be addressing the specific teachers' experiences with authentic assessment rather than focusing solely on how authentic assessment affects changes in instruction. Previous studies also primarily focused on the impact of a large scale assessment project that was imposed on teachers. My study will address the experiences of single teachers attempting to incorporate authentic assessment in their mathematics classrooms.

In studying teachers' experiences, Rowley, Brew, and Ryan (1996) reported that many themes emerged but they chose to address the three themes of professional practice, curriculum, and choice. My study will also be recognizing emergent themes and perhaps will be able to address other areas that Rowley and others did not address. For instance, in the study by Rowley, Brew, and Ryan (1996), teachers experienced dilemmas concerning traditional practices versus authentic assessment and felt pulled in two different directions. In my examination of emerging issues, I explore, describe, and clarify the types of dilemmas faced by teachers using authentic assessment. Some studies also reported that informal in-service settings seemed to be
most supportive. This, too, requires further probing to determine how this can be achieved and how it gets played out.

In summary, previous studies have brought forth many issues that require further exploration. In spite of the push for authentic assessment and the burgeoning implementation of large authentic assessments, areas remain that require further scrutiny. These issues concern the scarcity of research in secondary school mathematics classes, the insufficient exploration of the dilemmas that teachers face as they implement authentic assessment and how they deal with those dilemmas, the need to explore and develop effective teacher support, and the lack of detail about the development of teachers’ professional knowledge as they effect authentic assessment in their classrooms. My study specifically addresses these issues in order to clarify the practices, dilemmas and concerns of teachers implementing authentic assessment, and recognize comprehensive methods of support and preparation for these teachers. Thus, mathematics educators can determine how to assist teachers in making meaningful assessments of their students.
Chapter Three

Method

The following section will outline the need for a qualitative approach in this inquiry, my role as a researcher, the research setting, design of the inquiry, data collection, description, interpretation and analysis, and ethical issues.

3.1 The Need for a Qualitative Approach

My affinity for qualitative research lies in a quote by Sarason: "Educational change depends on what teachers do and think - it's as simple and complex as that" (Sarason, 1971, p. 193). I believe that curriculum is set, educational policies put forth, instructional strategies are developed but the true curriculum, educational philosophies, instructional and assessment practices are those that are being played out each day in the classroom. Qualitative research gives us the means to explore what is happening in classrooms and how students and teachers are making sense of their world. A qualitative research project was necessary to answer the research questions of this study.

In this study, it was necessary to become familiar with teachers who use performance assessment techniques in their secondary school mathematics classrooms and to explore what they do. The questions of the study were: how is authentic assessment played out in the classroom, what types of problems are teachers encountering with authentic assessment, and where and how do these teachers gain
support and assistance? Answering these types of questions required interviews, notetaking, document analysis, maintaining log books, and observation over time. Qualitative research chronicles teachers' perceived successes or failures with authentic assessment and provides the rich detail necessary to answer the research questions.

Qualitative inquiry - in this case the study of schools or classrooms - can provide the double advantage of learning about schools and classrooms in ways that are useful for understanding other schools and classrooms and learning about individual classrooms and particular teachers in ways that are useful to them. (Eisner, 1998, p. 12)

3.2 My Role as a Researcher

Before beginning this project, I had previous experience with qualitative research and therefore developed interview, transcription, and observation skills. I also had brief experiences as a guidance counselor and I discovered that the active listening skills I had developed in that capacity were very applicable to interview settings in research. Observation and recording skills were developed through coursework in qualitative research methodology and constantly practicing the ability to “see what counts”, as Eisner (1998) would suggest that the ability to see what counts is what differentiates novices from experts. I am also committed to seeing with an open mind rather than being confined to only seeing what I think should be there. My intent is to gain insight into the experiences of others rather than to allow my biases to interfere with what I see.

I also have over twenty years of experience as a mathematics teacher and Department Head which gives me an understanding of mathematics education and in particular, the culture of a classroom teacher. I, too, have experimented with and
implemented authentic assessment techniques in my classroom and have worked with teachers to develop alternative assessment strategies.

3.3 The Research Setting and Gaining Entry

I worked with five teachers who chose to incorporate selected authentic assessment techniques in their secondary school mathematics classroom. The teachers themselves were at very different stages in their career and, consequently, issues of experience could emerge. As well, they varied in their expertise with authentic assessment, again bringing forth differences. There were several issues to consider in the selection of participants. The number of participants needed to be large enough to have some divergence to bring relevant issues to light but needed to be small enough to reasonably collect sufficient data to give me the rich detail that I required. Five participants seemed both workable and sufficient. Another issue was the selection of the participants. Hammersley and Atkinson (1983) suggest that the selection of participants in a case study should be done through purposive sampling. My primary requirement in choosing teachers to work with was that they used authentic assessment to some extent in their mathematics classroom. Secondly, I selected participants to create a mixture of levels of experience with both teaching mathematics and using authentic assessment. The teachers came from four different secondary schools. Based on my experience, I knew that it would be unusual to find five mathematics teachers using authentic assessment within the same school. However,
two of the teachers work collaboratively at the same school and thus wanted to work together on this project.

Gaining entry into the research setting was fairly straightforward. At the conception of this study, I had been involved in a working group which was to create a network of teachers who were using authentic assessment in their mathematics classrooms. The group's purpose was to support one another and to share materials and ideas. There were several willing participants in the group and also some of the group members suggested other teachers who were not involved in the "Assessment Group" but were using authentic assessment and would be interested in participating in the study. Due to contract disputes and the ensuing temporary withdrawal of extra-curricular activities, the formal "Assessment Group" disbanded. However, the five participants and I met as a focus group on two occasions during the study (1998-1999) to discuss assessment.

At the initial stages of this project, I was surprised at the willingness of the participants to become involved in the project. Because of my previous work with some of these teachers, there was a baseline of trust that helped me gain entry to their individual situations and to the qualitative data sought.

Whether or not people have knowledge of social research, they are often more concerned with what kind of person the researcher is than with the research itself. They will try to gauge how far he or she can be trusted, what he or she might be able to offer as an acquaintance or friend, and perhaps also how easily he or she could be manipulated or exploited. (Hammersley & Atkinson, 1983, p. 78)
I was grateful that the participants trusted me enough to allow me to enter their world. Most of the interviews were done outside of class time, and access through individual school principals was sought before classroom observations took place.

3.3 Design of the Inquiry

The purpose of this study was to document the practices, beliefs and concerns of teachers as they carried out authentic assessment practices in their classrooms. Therefore it was necessary to conduct my research in a way that unearthed their practices, beliefs and concerns through multiple methods of data collection. These methods included a preliminary interview to present the project and answer prospective participants' questions. This was followed by four sets of interviews, one at the beginning of the project, two in the middle (following each of the observations) and one at the end. In most cases, the first interview brought forth the extent to which authentic assessment was used in that teacher's classroom, the teacher's views on mathematics education, resources that aided the teacher with authentic assessment, and areas that created stumbling blocks to implementation. There were also two focus group meetings for teachers to discuss their assessment practices with one another. These served as support as well as an exchange of ideas. I observed each teacher's classroom on two occasions when they were using authentic assessment to note how assessment practices were played out. This gave me a context in which to place the practices that the teachers spoke of in their interviews. Each observation was followed by an interview, sometimes in person, sometimes by telephone due to hectic
schedules, to obtain the teacher's perceptions of the classroom activities. Throughout the study, samples of authentic assessment instruments that the teachers used as well as school or department evaluation policies that would affect on assessment practices were collected. Each teacher maintained an assessment log book in which they frequently recorded their use of authentic assessment and any comments concerning the particular assessment to supplement the interview and observation data. In most cases, they also included samples of the activity, samples of the assessment and actual student samples to fully "round out" their brief description. I also maintained fieldnotes and my own journal throughout the research.

3.4 Data Collection

The collection of data for this study took place from April 1998 until March 1999. The data collection included a preliminary interview, an initial data-gathering interview, two classroom observations followed by post-observation interviews, a final interview, assessment logs and samples of assessment activities, and two focus group interviews.

3.4.1 Preliminary Interview - Invitation to Participate

Initially, the participants were interviewed so that the project could be explained to them and their questions answered. They also were assured of anonymity by changing names of participants and schools, confidentiality, and other ethical aspects of the project. After receiving these reassurances, each participant signed a consent to participate form.
3.4.2 First Interview

I interviewed each participant for approximately one hour in their initial interview. These interviews were audio taped and transcribed. A fundamental principle of qualitative interviewing is to give a structure within which respondents can express their own understandings in their own terms (Patton, 1980). This first interview helped to capture how, what, and why the teacher is using authentic assessment and set the stage for future discussion. Each participant described their background and school setting, discussed their views on mathematics education, their role as a teacher, an overview of their assessment methods, as well as any concerns, dilemmas or difficulties that they have encountered. It was an excellent opportunity to gain the teacher’s perspective and to explore how the teacher views his or her world.

We cannot observe how people have organized the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things. The purpose of interviewing, then, is to allow us to enter into the other person’s perspective. The assumption is that that perspective is meaningful, knowable, and able to be made explicitly. (Patton, 1980, p. 196)

These initial interviews established the extent to which each teacher uses alternative assessment and the purpose for which they use it. They also served to address the issues of each teacher's knowledge, beliefs, and attitudes about mathematics and mathematics learning, and how these relate to their experience with authentic assessment.
I began most of the interviews with the participant providing background information about their education, experience and current school situation. In interviewing, I used open-ended questions, applied active listening skills, and endeavored to hear the teacher’s voice. In most cases, the participants were able to supply a wealth of information with very little prompting. I audio taped and transcribed all of these discussions and while transcribing, it was evident that it was the teacher’s voice that I was hearing more than my own. I felt that the teachers’ willingness to speak was a sign of their trust in me. “It is surprising how much people are willing to say to those whom they believe are really willing to listen.” (Eisner, 1998, p. 183) The teachers readily talked about their view of mathematics and the variety of things they are doing in their classroom.

3.4.3 Assessment Log Books

In order to gain a view into the teacher’s world relative to authentic assessment, I wanted to gain as much access as possible to each teacher’s use of authentic assessment and their feelings about that use. In Kulm’s (1994) study, teachers kept a journal of classroom work and activities with a focus on assessment implementation. Teachers were encouraged to record approaches to assessment and how they worked, along with reflections, good ideas and special classroom episodes. Shulman (1986) suggests that in order to understand adequately the choices teachers make in classrooms, the grounds for their decisions and judgments about pupils, and the cognitive processes through which they select and sequence their actions while
teaching, it is necessary to study their thought processes before, during, and after teaching.

While it was not possible for me to be in five schools at the same time, I wanted to capture teachers’ thoughts as they happen. Therefore, I asked each teacher to keep an assessment log book. I recognized that a teacher’s day is filled with many tasks that are more immediate than recording their reflections. Therefore, I considered this type of a journal to be more of a log or record of uses of assessment in their classroom and I realized that I might only expect a minimum amount of reflection. I provided each teacher with a duotang filled with recording sheets that suggested the types of information they should record: date of assessment, type of assessment, comments on how it worked. I thought that this structuring may appear less burdensome than a blank piece of paper waiting for their reflective response.

They received their assessment log book when they had their initial interview. I explained that I would be pleased with any entries and therefore, they did not have to feel that it had to be a comprehensive, time-consuming, record-keeping task. I encouraged them to record assessment activities that were new, or worked well, or caused frustration. Also they could record ideas that came up that could not wait for the next interview or reflections on their teaching.

I was surprised at the attention the participants paid to the assessment log book. While every participant wrote in the book, some were very diligent about continuously writing, and others collected their thoughts before the interviews. All of the participants inserted copies of assessment activities and often copies of student
work related to the activity in the back of their log book. Thus, in their reflections they would refer to the copy of the activity as though it were an appendix. I felt that it was helpful because it provided me with data that I did not gain through interviews or observations. I could gain a sense of the continuum of experiences occurring in the classroom rather than the single events that occurred on my observation days.

I also kept a journal throughout the project to record observations of classroom activities, describe settings, dates and times of interviews, and to write my own thoughts, impressions, and ideas that I wanted to be able to recall in my writing. Note-taking is an important tool for conducting qualitative research because notes provide the reminder, the quotations, the details that make for credible description and convincing interpretation (Eisner, 1998). Often, the circumstances of an interview or observation can be relevant but this information is not readily visible in an interview’s transcript. “What researchers record when they take notes depends initially upon their ability to perceive what is meaningful and significant: this too is the act of imagination at work” (Eisner, 1998, p. 188). With this study taking place over a full year, I needed to record my thoughts as they happened so that they could be recalled when needed.

3.4.4 Gathering of Samples of Assessment

Through the assessment log, and both post-observation and other interviews, participants submitted and described authentic assessment instruments that they have been using. These included ideas for journal writing, scoring rubrics, portfolio
handouts, self- and peer-assessment checklists, observation charts, performance assessments or any other authentic assessment tools that they used. They also referred to department or school assessment policies, such as reporting procedures, that had an impact on their assessment practice. In Kulm's study (1994) teachers handed in tests as well as authentic assessment instruments that they used and these were very useful. Eisner (1998) notes that "Another important source of information about schools and classrooms is the records and artifacts that frequently reveal what people will or will not say" (p. 184). It is important to examine the types of assessments that are constructed for these artifacts provide a glimpse of what teachers feel are important. As suggested by Eisner (1998), assessment data reveals much about the values that are expressed in any particular classroom.

Indeed two of the most significant indices of educational values are the kinds of content and processes that are elicited through the assessment instruments used, and the kinds of responses that are considered acceptable. Such features have much to say about what teachers and test makers value and what is conveyed as important to students. (Eisner, 1998, p. 184)

The participants were more than willing to share their materials with me. For example, I might meet one of them at a workshop or seminar and they would immediately hand me something that they had just tried. "Here, I tried this last week and let me tell you how it went" was a common occurrence over the coffee urn at a school board function on mathematics education. In fact, I had gathered so many interesting activities that I collected them and made bound copies for each participant to be shared at our final focus group meeting. In that way they could share the
unique activities that were occurring in their classes as well as satisfy their need for new resources. Many of these resources are included in the Appendices.

3.4.5 Observation

Each participant was observed twice during the project during a class (of approximately one hour) in which they were using alternative assessment techniques. These settings provided a context and information about how assessment techniques are implemented within the participant's classroom. I was also able to observe student response and teacher feedback. These are significant issues in describing the authentic assessment activity and the extent to which a problem solving context is used. Field notes were taken and then transcribed. Through observation, I could describe the setting, the activities in the setting, and the people participating in the activities. As supported by Patton (1990), this allowed me to better understand the context within which the program operated, and allowed me to see things that may routinely escape the participants.

As well, observation of the classroom allowed me the opportunity to see what people do and say and how they do and say it. Schön's (1983) notion of reflection-in-action captures an important aspect of a teacher's practice.

The lesson plan must be put aside then, or else it must become a rough ground plan for action, a skeleton around which the teacher develops variations according to her on-the-spot understanding of the problems of particular students. Curriculum becomes an inventory of themes of understanding and skills to be addressed rather than a set of materials to be learned. Different students present different phenomena for understanding and action. Each student makes up a universe of one, whose potential problems, and pace of work must be appreciated as the teacher reflects-in-action on the design of her work. (Schön, 1983, p. 333)
The idea that teachers respond to the emerging particulars of a situation holds as well for the practice of authentic assessment. Observations helped me understand what teachers are meaning when they talk at a more abstract level in interviews about their use of authentic assessment activities.

Each observation was followed by a post-observation interview of varying length. Ideally, this should occur shortly after the observation, while the events of the setting were fresh in both the participants and the observers mind. However, reality dictates that this is not always possible. At the end of a class period, a teacher frequently has to go to another class, and frequently lunch-time and after school time are filled with meetings, photocopying and preparation chores, informal tutoring, or just winding down. So, at times, we had an informal chat towards the end of the period which may have been followed with a telephone interview that evening. Frequently, the class that I observed may have been in the middle of an activity that spanned several days and the teacher and I would agree to have our post-observation interview when the activity had been brought to fruition. This made it easier for the teacher to reflect on what he or she might have done differently and to describe how the subsequent events unfolded. In one instance, I observed an introduction to portfolios and the participant and I met after the first portfolio submission so that the teacher could talk about her impressions of the student submissions. In another, I observed the second day of a four day activity that had student presentations as a culminating event. We delayed our post-observation interview until after the student
presentations. Flexibility in timing was a key to addressing my needs and respecting and valuing the teacher's own agenda and time.

3.4.6 Focus Group Interview

All five of the participants were brought together on two occasions to discuss and share techniques that they have been using. The focus group interviews were audio-taped and transcribed. I had decided to include this research technique because previous studies by Morony & Olssen (1994) and Rowley, Brew, and Ryan (1996) indicated that informal discussions are not only informative, they are a source of support for teachers. I found this to be very true. The teachers compared notes on assessment practices, challenged one another's beliefs, discussed concerns and dilemmas that they were having and basically offered support to one another while supplying me with rich data.

The first focus group meeting was held after school at my home. All participants attended and due to our lively discussion, we went over the hour that I had set aside. Since the format of this focus group interview was to share ideas on authentic assessment, I would prompt the discussion with occasional open-ended questions. Everyone was an active participant. I saw one of the participants, Miriam, several days after the focus group meeting and she reported that it was one of the best professional dialogues that she has had in a long time.

The positive feedback that I received from the participants and the recurring mention of their lack of resources, time, and dialogue encouraged me to take a different approach with our next focus group meeting. Each participant received their
copy of the bound book of their submitted activities, sectioned by participant. Most of the meeting was spent with each participant describing their activities and giving details regarding what class it was used with, how successful it was, and what modifications could still be made. For me, this added greater detail to my observations, interviews, and reading of the participant's assessment log. The participants had a chance to share ideas, dialogue with their colleagues, and to obtain new resources.

3.4.7 Final Interview

I had a final interview of approximately one hour with each participant which was audio-taped and transcribed. Occasionally, due to scheduling constraints and sensitivity to my participants' time, these were often coupled with the interview that followed the final observation. The purpose of the final interview was to confirm the data that I had gathered and organized from the previous interviews, focus groups, observations, and assessment log books. Before interviewing each participant a final time, I had roughed out his or her case study. Therefore, if I noticed any gaps in my details, inconsistencies, or misunderstandings then those issues could be clarified at this point. I also had the opportunity to see growth in experience with authentic assessment. For instance, one participant began the project with a desire to explore the use of rubrics and at the end of the project he had developed and used several rubrics and chronicling this development was an important component to his case study.

The final interview also intended to bring closure to the project. However, I discovered that this was not as easy as it sounded. Having built a rapport with the
participants, I still find that when we meet at conferences, workshops, Mathematics Department Heads meetings, or on committee work, that we continue to exchange assessment ideas which I take as a sign that we created a necessary dialogue.

### 3.5 Description of the Data

Each case study is divided into analogous sub-headings: general background of the participant and setting, the participant's view of mathematics and assessment, his or her general use of authentic assessment, specific examples of authentic assessment activities, stumbling blocks that the participant has faced, and sources of support for the participant. As described by Wolcott "Description addresses the question, 'What is going on here?'" (Wolcott, 1994, p. 12).

Transcription of interview tapes and observation notes was ongoing throughout the project and occurred soon after each interview or observation was completed. As I transcribed the tapes, I would reflect on the individual's answers to some of my research questions such as: what are the participants doing and why are they doing it, to what extent do they use authentic assessment, and what are the specific examples of their assessment practices? These items were easily identified and hand coded on the transcripts.

The description of the data includes extensive quoting of the participants. Spoken language is very different from written language and I found it necessary to edit some of the quotations for readability. The editing does not change the intent or meaning of the participant but rather reorganizes phrases, removes pauses, and
makes the participants voice clearer. For an example of my editing, see Appendix G which provides a sample from the transcript followed by an edited version of the transcript sample.

3.6 Analysis and Interpretation of the Data

Hammersley and Atkinson (1983) claim that "In ethnography the analysis of the data is not a distinct stage of the research" (p. 174). I found this to be true for I was constantly reviewing and analyzing field notes, interview tapes and transcripts.

Bogdan and Biklen (1992) state that:

Data analysis is the process of systematically searching and arranging the interview transcripts, fieldnotes, and other materials that you accumulate to increase your own understanding of them and to enable you to present what you have discovered to others. Analysis involves working with data, organizing it, breaking it into manageable units, synthesizing it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others. (p. 145)

My data analysis matches Bogdan and Biklen's description. I included all of transcripts of interviews, observations and focus group working sessions as well as field notes and participants' assessment log books in my analysis. My initial research questions helped me categorize my data since I was looking for what teachers were doing, why they were doing it, how it was "played out", what dilemmas were faced, and what helped their practice. Within these categories themes arose that needed further coding. Issues emerged as the research was pursued and again through the analysis when patterns where identified, categorized and re-organized several times.
Analysis of the data was on-going. I often would transcribe the interview tape immediately after the interview, read the transcript, and then loosely identify themes and categories with penciled notations in the margins of the transcript. As I listened to my participants speak through the audio tapes during transcription I heard both common themes and individual differences. For instance, a similar dilemma might appear for several of the participants, yet there could be differences in how each participant handled the dilemma.

Although my intent was to use a qualitative research software to help analyze the data and pull out significant themes I found that, in the end, it was not necessary. Initially, as I typed a transcript I would put it into a format that could be analyzed by the software. I also organized and catalogued the various transcripts to use with the NUD*IST software program. However, as I typed and re-read the transcripts in preparation for further interviews, I found that I was already analyzing the data. The common themes became apparent through reading the transcripts and I found that I was doing my analysis without the use of the software. Thus, even though I had purchased and become familiar with the software, I found that it was not necessary to use it. Wolcott suggests that qualitative research software helps us process data but:

Contrasted with the weeks and weeks in which she [the researcher] will be engaged in mechanical processing, the truly analytical moments will occur during brief bursts of insight or pattern recognition, some of which must already have occurred for her to have identified even the most rudimentary categories and coding procedures. (Wolcott, 1994, p. 24)

Thus, my analysis took place throughout the research project as I coded and re-read transcripts of previous interviews with each participant before subsequent interviews.
At times, I truly related to the phrase "immersed in the data". Once the project was nearing its final stages, I re-read and re-coded all of the data to be sure that I could see the full picture.

These themes provided a structure to the writing of the findings. Chapter Four describes in detail what each of the participants was doing and why they were doing it. Within this structure, selected material has been used to illuminate these themes. Chapter Five delves into common themes of the five participants particularly dealing with common dilemmas and how each participant deals with the dilemma. Interpretation of the data addresses issues of meanings and contexts such as "What is to be made of it all?" (Wolcott, 1994). The discussion also compares findings from similar studies. The last major section of Chapter Five attempts to answer the question of meaning by addressing what is needed to increase the participants' expertise in authentic assessment and to make assessment truly more authentic.

3.7 Ethical Issues

Written consent of each teacher was obtained prior to the beginning of the research. The interviews occurred outside of school time and therefore administrative approval for the interviews was not required. Permission of the principal of each school involved was obtained prior to classroom observation. It was clearly stated that this research is not evaluative and students' individual work or progress is not part of the research project. A full Ethical Review was approved prior to the commencement of this research.
Personal ethical issues that come into play include the time commitment of the teachers involved in the project and the risk that these teachers take in allowing access to their work. These are both areas to which I have been extremely sensitive. Although it was clear that my intent was not to evaluate, teachers still likely wonder how they are perceived.

On the one hand, to be able to create the psychological comfort that makes it possible for people to reveal what they think, feel, and fear is the mark of a good field researcher. On the other hand, the people interviewed might have regrets later about what they have said. They might feel vulnerable. (Eisner, 1998, p. 218)

Although researchers negotiate participation through their first set of interviews by giving guarantees of privacy, confidentiality and anonymity, there are other ethical considerations. The researcher must also guarantee that the participant's views will be taken into account and that the participant will be able to consider the researcher's interpretation of their actions or comments (Hunt, 1987). I attempted to do this whenever possible by beginning subsequent interviews or meetings with a recap of the issues that we had discussed on previous interviews, and then allowing the participant a chance to validate, refine or refute my perceptions.
Chapter Four

The Case Studies

This chapter gives a description of five teachers using authentic assessment in their secondary school mathematics classrooms. These case studies record the teachers’ reflections as they integrate authentic assessment into their mathematics program and are based on data gathered through a total of twenty interviews, ten observations, two focus group meetings, and examination of each participant’s log assessment log book. For each case, I provide a description of the school, the educational and teaching background of the participant, their “philosophy” of teaching mathematics and their rationale for using authentic assessment. I then describe their general use of authentic assessment, followed by detailed examples of assessment activities that they have used. I cite those factors that help or hinder the participants’ use of authentic assessment. These dilemmas and aids will be explored and discussed in greater detail in Chapter 5. I will conclude each case study with a summary.

4.1 The Case of Gwen

Gwen was completing her sixth year of teaching when this study began. Her teaching experience includes a first year of teaching in an elementary school followed by five years of teaching secondary school mathematics and computer science. Gwen is currently taking courses towards a Masters of Education degree. Her undergraduate degree was in Physical Education. She obtained her teaching
qualifications in mathematics through Additional Qualification courses in the summer and fall following her first year of teaching.

Gwen is currently teaching at Glenview Secondary School, a non-semested multicultural school in the suburbs of a very large city. Glenview has approximately 1800 students, a main building and close to fifteen portable classrooms behind the main building. The school is just under twenty years old and upon entering one is struck by its cleanliness. The administration has high expectations of both students and staff in responsibility, demeanor and mutual respect.

Glenview has a unique grade nine program that began in 1993 when the Ministry of Education implemented a policy known as The Transition Years. At that time, Glenview's staff worked together to formulate a list of the learning outcomes that they expected grade nine students to attain. This list included both subject specific and generic outcomes and was divided into the categories: Subject Knowledge and Skills, Problem Solving Skills, Work Habits, Independent Learning Skills and Group Learning Skills. The grade nine report card became a list of these outcomes and had a rating scale beside each outcome ranging from "Below Grade Level" to "At Grade Level" to "Above Grade Level" [Appendix B-1]. A student would receive a separate report card from each of his or her eight teachers. Each subject had chosen the specific outcomes for the Subject Knowledge and Skills category but the other outcomes were the same for all subjects. During the implementation of this report card, staff also worked on developing the "Glenview Benchmarks" which were descriptors of each level for each outcome so that teachers
were using the scales with some consistency. There were no letter grades or percentages on this report card, rather, there was a check mark placed on each outcome's scale at the appropriate level. The report card has evolved since then but still maintains rating scales related to a list of learning outcomes. The significance of there being no marks in grade nine will be referred to on several occasions by both Gwen and Julia. The other grades, grades 10 through Ontario Academic Credit (OAC), or pre-university, year used a more traditional report card with numeric percentages given for each subject.

Gwen has been actively involved in developing the grade nine program. She has also participated in field testing the Provincial Standards in Mathematics along with four other teachers in the school. On a broader level, Gwen worked on a board curriculum writing team to develop grade seven, eight and nine mathematics activities and assessment aligned to the Provincial Standards.

4.1.1 Gwen's View of Mathematics and Assessment

Gwen uses authentic assessment because she believes that it better reflects the process of learning mathematics rather than the final product or the answer.

It’s the paper and pencil tests that test the final product, they don’t test a lot of the thinking that’s going on. . . . But when they [the students] look at a process or an assessment like peer evaluation, or a self-evaluation, they’re able to look more at the entire package to see how they’ve grown through it. (Interview transcript, April 23, 1998)

Gwen's focus on the process of learning is demonstrated in both instructional activities and assessment. Gwen believes that the problem solving activities that she incorporates with her assessment techniques encourages higher level thinking skills.
I actually find that the assessment helps with the higher level [thinking], because you don’t tend to teach the higher level thinking skills. You may ask them to ‘do the extra question in the textbook’ or ‘try this’ but you’re not giving a lot of kids the opportunity to show you that they can exceed a lot of the expectations that are outlined in the standards [Ontario Provincial Standards for Mathematics]. Getting that last level is very difficult. Unless you provide activities that allow them to get to that level, a lot of times, you can’t evaluate it, and a lot of people misinterpret that. (Interview transcript, April 23, 1998)

Gwen also believes that building students’ communication skills in mathematics is a component of their development of mathematics concepts. She often uses pair and group work and expects students to explain their problem solutions to one another or to teach one another through “Think Pair Share”. Gwen is beginning to incorporate group presentations into her repertoire and reports:

They don’t get enough chances to present in groups so I tried to organize something to allow them to present. (Focus Group Interview, February 11, 1999)

Much of Gwen’s view of mathematics rests on building from the concrete and moving to the abstract. She attributes much of this to her elementary experience.

I think it’s probably my elementary background that makes me believe that a lot of things have to start concretely. (Interview Transcript, April 23, 1998)

She believes that her elementary background also encourages her to focus on the whole child.

When I taught in elementary, there was no mark. We evaluated students at different levels: below grade level, above grade level. In a way, they [elementary teachers] worry about the outcome of the student rather than the mark. Can the student show you how they’re learning rather than the final evaluation itself? It’s definitely a different way of thinking and I argue this all the time. A kid can make the same mistake over and over on a test and still know a lot more than you’re letting him show you because you’re just asking him to show you this type of question. And yet if you ask them to make up a question, they can make
a question that's harder than anything you would have ever asked them. If you ask them to show you what they could do, it gives them more hope I think. It gives them greater chance for success with little activities here and there. And if they know that you value what they're doing then they'll think that it's not just an activity that you do for the sake of doing something different. It's important. (Interview transcript, April 23, 1998)

Gwen believes in developing a student's self-confidence in mathematics, ownership for his or her own learning, and pride. Her reflections on a group activity state:

I like that they took pride in their work when they did it on paper. They had a stake in it. They enjoyed it. They must have enjoyed it because they seemed pretty focused and that was a hot day too. (Interview Transcript, May 25, 1998)

Her reflections on her use of portfolios also reflects these views:

I think it's a good way to write about themselves. It helps them to realize that they are doing okay. They know what they are doing and what they need to do and the writing it down brings it out more. Well, I was really intrigued by the process. They wouldn't take the time to think about it that way without writing in the portfolio. (Interview Transcript, November 23, 1998)

Gwen brings forth the idea of values and showing students what she as a teacher values and how this is reflected in her assessment:

I think that they [students] should value that they're attempting to do their best in that area. I don't expect every student to be a mathematician, but realizing that they can take risks, that their answer with some founded knowledge is worth trying, is important. I think too often the reason that kids get turned off is because their answer is not right, not the final answer. And I think one of the things I do value, or that my kids know that I value is the process, that the final answer doesn't have to be there. I don't care what the final answer is, as much as I do the kids working through, and even in their homework, most times, I just evaluate it in terms of have they put forth their best, have they tried what they can, asked questions, talked to other people about it? And I do value that the answers are correct, that's obviously a concern, but I value other things as well. They need to listen to one another. If you're doing a peer-evaluation then what they have to say
should be important to what you want to do. (Interview transcript, April 23, 1998)

Gwen values that students take risks, ask questions, work with others and make every effort they can to solve problems.

Throughout my work with Gwen, many of her comments referred to her work with grade nine mathematics classes. This is especially true when she speaks of focusing on effort and developing a solution rather than having the “correct final” answer. When I asked her whether this viewpoint would hold true for all grades, Gwen responded:

In grade twelve I probably would look for more right answers, I think. Or maybe I’m expecting more from them in terms of assuming that they’ve already accomplished the other, and gotten to that point, where the others haven’t had the opportunity to. (Interview transcript, April 23, 1998)

In further searching for Gwen’s views of mathematics, I inquired of her own experiences of mathematics as a secondary school student. Her experience as a student was a fairly traditional one.

I liked math a lot, but it was easy, easy to memorize. I remember being in grade eight and my teacher giving me the grade nine text book and saying, “start this algebra unit”, and I know I could figure out by the examples why a’s were added together [in adding like terms in algebra], but I had no idea what it meant. And in the latter years of high school, some student was always going to get forced to throw the homework question up on the board, so we made sure it was done, and done correctly because you didn’t know who was going to get picked that day, and that was a fearful thing. I didn’t like that. It was always chalk and talk in class, always sitting at the desk. (Interview transcript, April 23, 1998)

Pursuing this further I asked “Did you think about math as, I think you mentioned it, as stuff to memorize and algorithms and did you enjoy that?”. She responded:
I did until, probably, until OAC [grade 13 or the pre-university year] because then it became "You better understand it." We didn't have the computers and the technology that we have now in the math program, and I think that's where I focus more of my energies now, on using the technology [in teaching mathematics]. (Interview transcript, April 23, 1998)

Gwen is referring to her use of computer software such as Geometer's Sketchpad, Green Globs, Zap-A-Graph, as well as graphing calculators to aid students' understanding of exploring and visualizing mathematics.

4.1.2 Gwen's Use of Authentic Assessment

Gwen's approach to mathematics instruction combines a traditional approach as well as the use of open-ended problem solving, a variety of group work, reflection through portfolios, and an emphasis on communication in mathematics. Gwen uses a combination of traditional assessment practices, such as end of unit tests and intermittent quizzes, as well as authentic assessment, such as self-evaluation, performance assessment, checklists for observation, and rubrics. She uses authentic assessment to a much greater extent in grade nine than she does in the other grades that she is currently teaching. She attributes this to how well authentic assessment fits to the grade nine report card.

When asked what types of assessment she uses, she responded:

Observation, self, peer, evaluation often. A lot of the traditional things, even though they are the paper and pencil tests, a lot of the times I'll have them make up problems in the test and show me what they know. For instance, "Make up any factoring problem." . . . and I find I get a lot from that; those types of ideas from them. Presentations, groupwork, lots of things like that. (Interview transcript, April 23, 1998)

She also uses self-assessment and reflection with students:
I'd use them [authentic assessment techniques] at other times as well. Toward the end of a unit and at the end of the course, I have had them reflect on how much effort they put into the unit, as well. (Interview transcript, April 23, 1998)

She mentions that she has used authentic assessment in classes other than just grade nine. She is also teaching grade ten enhanced mathematics, grade twelve advanced mathematics and grade ten computer science.

I've tried them in my grade ten class, my grade twelve advanced, and in my three computer classes this year too. Actually I did a rubric for an activity for the computer class. It worked really well. (Interview transcript, April 23, 1998)

Gwen has had some experience working with rubrics.

I haven't used a lot of rubrics but I think that if they [the students] know, if they can make the criteria for the rubric, then they live up to, or they produce the highest level they can rather than if they just think, 'I'll just write the answer down, that's acceptable, that's the answer'. But if they know that much more is expected of them to be at that level, then I think that's important too. (Interview transcript, April 12, 1998)

Although Gwen mentions that she has not used rubrics extensively, she has used them in many of her classes on many of her activities. She has stated that being involved in this project has encouraged her to explore and extend her use of rubrics.

4.1.3 Examples of Assessment/Problem-Solving Activities

Gwen's use of authentic assessment was illustrated through documents or sample sheets of activities, the assessment of those activities as recorded and included in her log book, reference to activities in her interviews, and also first hand through my observation of her classroom. In her grade nine mathematics class, Gwen uses group and individual activities intermixed with a traditional approach to teaching
mathematics. One activity she uses in introducing graphing relations in grade nine presents students with a description of a scenario that they would then have to graph.

We spent a couple of days in the last unit on relations, looking at problems with a scenario. For instance, there was the "choo choo train" scenario where the train starts at the station and travels for 10 km at such and such a speed, stops for lunch, and other events, and they have to draw the graph of the relation. We did a lot interpreting and making up your own story by looking at the graph. At the end of the unit, I gave them each a problem about a pop machine. The machine is half full when you start at the beginning of the day and no one has access to it for the first hour and the last hour of the day. I give them a whole scenario, and they had to make a scale on the vertical axis which could have been cans, either full or empty cans. They had to interpret it [the scenario] and graph it according to what they saw. It was a blank graph and they put everything on it. Some put words, some put numbers, and they did quite well on it, actually. But everyone had a different interpretation of it. There's still things that you're specifically looking for but there were those that really understood, they really had it. (Interview transcript, April 23, 1998)

I asked Gwen about how she might assess students' learning related to this activity and she replied:

What I wanted to do with it, but haven't, was to take one classes' responses, there are two classes, and give them to the other class and have them sort and categorize the solutions. They could determine what would be a good solution and create a rubric . . . What I did was to basically make a little checklist for myself such as "Were they able to set it up?", "Were they able to interpret the question?". Most kids were [able to do that], in their own terms. I basically compared them to each other rather than "there's a good one" . . . I made notes on them. I haven't used a lot of rubrics but I think that if the students know and can make the criteria for the rubric, then they live up to, or they produce the highest level they can rather than if they just think, "Oh, I'll just write it down, and do it, that's acceptable, that's the answer". But if they know that much more is expected of them to be at that level, then I think that's important too. So that's the one thing I really wanted to do. (Interview transcript, April 23, 1998)
Gwen often refers to wanting to do more. She has many ideas as to how to extend the work that she is doing, however, lack of time is often a stumbling block.

I observed Gwen’s grade nine class for one day of a three day group activity. The class activity involved creating kits to make square patios.

This problem-solving activity [Appendix B-2] is a group activity where students are going into business to sell kits to make square patios. They are given the specifications for the materials needed to build these patios and the prices of each material. They then work through a series of questions to be able to generalize the cost of a patio that is \( n \times n \). Students have had previous work with patterning and generalizations in another unit. (Field notes, May 19, 1998)

Gwen began the class by placing a transparency on the overhead which displayed the evaluation criteria [Appendix B-3] for this activity and quickly read over the criteria to the class and then they were ready to start the project. My field notes describe the beginning of the class:

Gwen then gave clear directions for what materials were needed: paper, calculators, pencils. All students seemed co-operative as she spoke. She then gave directions for what they were to do next. This included who was in each group (she had determined the make-up of the groups), where they will move to form the group and when they will move.

Some groups started reading the problem and other groups were not very focused. After about 10 minutes, Gwen stopped them to review what they should be doing. She suggested that they should be starting with a chart for different size patios. “Remember, you are being marked on how you work in a group. Some haven’t read the instructions yet. You need to use your time well.”

Gwen circulated the work and gave each group a bag of manipulatives - toothpicks, bingo chips, pieces of paper. These manipulatives were to represent the different components of the patio - the tiles, frames, corners, and border stabilizers. Students soon began using the materials to make models of the patios.

After another 5 minutes, Gwen started to draw on the board and then interrupted the students to pay attention to the board. She drew a
In our post-observation interview, Gwen described the completion of the activity in the following two class periods. Gwen first brought the students' focus back to the problem and helped the students with questions that they had been stuck on from the previous day. She questions how much assistance she should be giving in these reflections during our interview:

At that time I guess a couple of things I thought about were: whether or not to give them more direction or to see how much they could do on their own? Especially with the patterning, one of the patterns was very tough and I kind of left it until the second day. At the beginning of the second day we talked about it but I was warning them, I probably tend to answer the questions with them, the ones that they get stuck on. (Interview transcript, May 25, 1998)

During the remainder of the period the students worked on completing their charts and preparing for their presentations for the next day.

They worked really well the second day. I had to help them a lot in terms of directing them, what I was looking for in question 6. It wasn't just "Give me a price". It was give me a scenario to give me a reason behind why you are breaking it down that way. And they were able to explain their reasoning. I think a lot of times in number 4, examples of companies, they were good with that, they came up with a lot of variety of examples but I had to stop and think about that. (Interview transcript, May 25, 1998)

When the students gave their presentations, Gwen was a bit disappointed because:

They presented on the second day as a group but with the chart part of it, the kids basically said "This is our chart" and it became very quick
and it felt that all of this work was anti-climactic. But now, I modified
the assignment a bit so that they would be more able to present and have
different presentations on the same thing. (Interview transcript, May 25,
1998)

This reshaped Gwen’s thinking about the focus of the activity.

I wanted to see their thinking as they presented. But they were good
listening to each other. I think that the presentation part is important. I
didn’t really think of the presentation part as being the focus but it
became clear to me that they don’t present enough and that is a major
part of organization as well. (Interview transcript, May 25, 1998)

Gwen is reworking the assessment of the activity to include presentation skills. In
fact, she is thinking of having several assessments throughout the activity to refocus
them.

I think that maybe rather than having a cumulative evaluation at the end
it might be better to have a little bit each day. Because it is such a long
activity. I didn’t realize that the activity would take that long. I had to
refocus them on why and what they were supposed to be doing.
(Interview transcript, May 25, 1998)

Gwen disclosed that although she will make some changes, she is pleased with the
activity.

I liked the activity a lot. . . I like the fact that they could draw or
construct different patios and come up with the chart. For them, there
were very few questions on that except for knowing how to use the
stabilizers because they were hard to see but that was a lot of them not
reading carefully as well. . . They had a stake in it. They enjoyed it.
(Interview transcript, May 25, 1998)

She also felt that the students did surprisingly well at recognizing patterns and
generalizing these patterns algebraically.

In the fall of the second half of this inquiry, I had the opportunity to observe

Gwen introduce a portfolio project [Appendix B-4 (a-d)] to her grade nine
mathematics class. This was the first time that Gwen would be using portfolios. She had gathered resources from other colleagues who had used portfolios with a variety of classes, and used these resources to shape a portfolio project for her own class. Gwen's portfolio project requires that students make regular submissions of two samples of their work approximately every month throughout the school year. They choose samples based on how the student feels the sample fits one of the categories outlined on the project handout [Appendix B-4a]. Each sample must have a reflection sheet [Appendix B-4b] attached to it that states the student's name, date of work and a full page response to the questions that pertain to that category. Students keep these samples in a folder that Gwen distributed on the day she introduced the project. The quality of the self-reflections is to be evaluated as a Level (1 through 4) and the assessment criteria or descriptors were also distributed to the students [Appendix B-4c].

The following is a brief description of the introduction of the project to the classroom:

The lesson was an introduction to portfolios followed by a pair/share on algebra. Students sat in pairs and as class was getting organized the students seemed responsive and respectful. Gwen began by asking them how many have had an experience with using portfolios. Some hands went up and some students groaned.

Gwen talked about the fact that the students had already done some writing in math class because they wrote about "me and math" toward the beginning of the course. Also she reminded them that she often has them make written comments about how they did on tests. She mentioned that this is called self-reflection and from what she had seen they are very good at it.

Gwen asked a student to read the first paragraph of the handout aloud. Gwen asked another student to read the categories and then Gwen
explained the categories. This process of a student reading a paragraph aloud and then Gwen explaining its meaning continued. Gwen selected students to do the reading rather than asking for volunteers. All students appeared to be focused.

The discussion then went to the quality of self-reflection. She asked a student what “quality of a self-reflection” meant and the student responded “You can’t just put it was good, there needs to be more detail in your reflections.”

Gwen explained that if a piece of work triggers a different idea than the ones addressed by the questions then they could check with her because the instructions were not carved in stone. The recording sheet also had the evaluation criteria on it and students were to note that through the course of the project there were 3 different audiences that they were to address: peer, teacher or other. Gwen asked for suggestions as to who would be a peer and students indicated that it might be a friend because they would be easier to talk to or a classmate because they knew what you were doing.

The 4 levels of quality of self reflection were described in detail. They then reflected, as a class, on an activity with dice that they had done on the previous Friday. Gwen asked under which category could that activity fall and why. One student said that it would be a problem solving activity and they were asked why? Gwen then asked a student if it could fall under determination. The students said “Yes, because maybe you got a good mark or maybe you had to stick with it.”

The folders were distributed. Students broke into informal chatter and then were called back together. Students were told to glue in the information sheets so they would always have them to refer to. Laura said “Will we have time to put something in it today?” Okay, we’ll find a piece of work that you can put in and discuss this with someone near you. A student asked: Could this be a test? Another asked what to do if more than one student wanted to use a group activity. “I did this with someone else, can I put it in?” Gwen responded that it could be photocopied. Gwen then clarified what they were about to do.

Then they set about to glue in their papers. Gwen reminded them by asking “What are you doing today?” One student clarified that they were to put their name on the folder, glue the green page on one side and the blue page on the other. “The other thing is you’re going to select 1 piece of work and discuss with your peer what category it might go in.” Again, they discussed what a peer is.
As they worked there was a lot of chatter. One student exclaimed “Excuse me, Miss, my peer is calling me names.” Students completed gluing their sheets in. Gwen said: “Okay, now that you’ve glued that in take a minute and look through your notes.” The students then picked out a piece of work and took turns discussing with their peer whether it met the criteria. Most students participated and talked through their work. Some of the comments overheard were: “Why did you choose this?” “Because I got a good mark.” The student then asked his partner what it would fit under and the partner responded “Something you’re proud of.”

When the students had finished choosing their piece of work and putting it in their folders Gwen said “Okay, close the folder. Now get out your algebra pairs assignment.” Gwen then collected the folders and said “Okay, take out a clean piece of paper and put the title and date on it.” The students moved on to another activity. (Observation Notes, October 27, 1998)

In our post-observation interview I asked Gwen why she chose to use portfolios with her class. Some of her main reasons include advocating writing in mathematics, recognizing student perceptions of their growth, and developing reflection on their own learning:

One of the reasons is to actually come up with particular forms of assessment where students can write a bit. . . . I thought that this would be a good time for me to try to work with portfolios. To also look at how students perceive themselves and their own growth. That’s really important to do as well. As I read through them, that became really clear. There are a lot of things that you don’t know about students. (Post-observation interview, November 23, 1998)

Gwen and I planned our post-observation interview to occur after the students made their first portfolio submission and Gwen had time to assess them. Gwen mentioned that many of them focused on tests as samples of their work and often used them as “something to be proud of”. Before handing in their portfolios, she asked students to use the rubric to rate themselves. She remarked that the students were very
comfortable using the rating scale and didn’t question the levels. As she assessed the portfolios she found that she usually agreed with their assessment.

I asked her what her reaction was when she was reading through the portfolios. She responded:

... I think it’s a good way to write about themselves. It helps them to realize that they are doing okay. They know what they are doing and what they need to do and the writing it down brings it out more... Well, I was really intrigued by the process. They wouldn’t take the time to think about it that way without writing in the portfolio... The kids will write to you in ways that they won’t speak to you. Especially the really shy kids... I think it will increase their comfort level... They are really insightful and some of them are really self-reflective. You wouldn’t get this from them in most other ways. However, I noticed that I have to give them more activities that will fall into these categories as well. (Post-observation interview, November 23, 1998)

Gwen was also able to provide specific examples of authentic assessment from classes other than grade nine. In her grade ten computer science class, Gwen used a programming assignment called “Math for Kids” [Appendix B-5a]. In this assignment students write a program that could be used by young children to practice addition facts. Students were also given options that could be added to the program to earn more marks. A rubric [Appendix B-5b] was included with descriptors of four levels so that students could clearly see the criteria to move from one level to the next as they added more features. Here she describes how things “worked”:

I did a rubric for an activity for the computer class. It worked really well... It was a program that had different levels and the levels were set out for you with the criteria of each level which would basically determine what their mark would be. Then I marked it, gave it back to them, told them what they have at the end - if they didn’t add anything else to the program. (Interview transcript, April 23, 1998)
Gwen also incorporated peer evaluation [Appendix B-5c] into this activity by having students evaluate one another's programs for their graphics quality and user-friendliness. Peer evaluators also worked from a rubric that incorporated the original rubric with additional criteria to evaluate the graphics quality and the user-friendliness.

I had the kids go around the class to two other programs [that had been written by students], run them, and see if they were supposed to be very user friendly, and the kids could understand what was going on and evaluate it in those terms. (Interview transcript, April 23, 1998)

Gwen observed that "the comments to peers were constructive and positive" (Assessment Log Book, entry on April 16, 1998).

Gwen has used self-evaluation and peer evaluation several times in this computer class. Another instance [Appendix B-6 a, b] was with students' judging of how their graphics program compared with others in the class. This "overall impression" component made up part of their mark on the assignment. Students have also been asked to self-evaluate their participation. Gwen noted that students are very conscious of the effort that they put into their performance and work habits and in fact, "most students evaluate themselves 'tougher' than I do" (Assessment Log Book, May 7, 1998 entry).

Gwen also teaches a grade ten enhanced mathematics class and gave me an example of her use of authentic assessment in that class. She gave them a geometry problem that required that they use the software Geometer's Sketchpad as an aid to their solution. When asked if she assesses what students do on Geometer's Sketchpad, she replied:
... I have two problems that I’m giving them next week that are open-ended that I’m going to have them assess on geometry sketch pad. The scenario is given to them and they have to construct a solution on the sketch pad. So that’ll be good, and then, I’m going to have them evaluate it. (Interview transcript, April 23, 1998)

4.1.4 Support for Authentic Assessment

I asked Gwen what resources, ideas, people or situations she found helpful in her implementation of authentic assessment. Her responses included colleagues, professional development, curriculum writing, resource books, and the emphasis in her school on assessing levels of achievement of outcomes rather than using marks in grade nine. Gwen gives an overview:

I would probably say that the influences of the department and definitely the grade nine report card concept have helped a lot. That whole change has definitely led to that type of evaluation or assessment. Also, the encounter with the writing team, changing the writing for those units at the board office taught me a number of things. Otherwise I would have been very unfamiliar with the levels [in the provincial standards]. It was something, the standards. I had no idea that they existed. And I don’t know whether the Teacher’s College of Ontario [Gwen did her teacher training in British Columbia] would have presented them [student teachers] with them here. So, coming from the elementary to secondary, that definitely was one of the major things. The writing, and seeing, going through some of the documents and trying to match up that with our report cards. (Interview transcript, April 23, 1998)

She elaborates on the benefits of the grade nine report card by saying that the report card encourages teachers to include more group activities and problem solving. She also finds it useful to see examples of “good problems” and other assessment activities.

I think that I have a really good understanding about what authentic assessment is, and I believe that it’s for the benefit of those involved, I just have to now apply it more frequently. I think I’m still stuck in
getting through this much of the curriculum and thinking that there’s only one way of getting through it, I think I need to see more examples, like I need to see people doing it more frequently. (Interview transcript, April 23, 1998)

Gwen also finds it very beneficial to work with others in developing and exploring new ideas. She finds that through discussion with others, her ideas grow and she has someone with whom she can share her successes and shortcomings.

It’s important, I think to talk to somebody, to work with other people who do it as well. I think to try to do it on your own, you’ll miss things that obviously can work better. But you need to have someone that has the same ways to use that, and be able to speak to at least one other person in that department. (Interview transcript, April 23, 1998)

This desire to work with others possibly led Gwen to suggest that another teacher from her school might also want to be a participant in this study.

4.1.5 Problems/ Stumbling Blocks

There are personal stumbling blocks that directly affect Gwen’s own implementation process. These include lack of time, a pressure to cover the content of the course, dilemmas regarding the amount of guidance she should give students in problem solving settings, and a lack of accessible resources and examples of good problems and appropriate rubrics. She also sees stumbling blocks to large scale implementation of authentic assessment in secondary school classrooms. These include a lack of understanding of authentic assessment among most secondary school mathematics teachers, an unwillingness to adapt new techniques, and difficulties with maintaining standards and consistency among mathematics teachers. In this section I will first address Gwen’s personal obstacles and then I will discuss the
obstacles that Gwen feels need to be overcome before authentic assessment could be used on a more global scale.

One of the biggest stumbling blocks that Gwen recognizes is time. When she first mentioned time I asked whether she meant a lack of classroom time or teacher preparation time and she replied:

Well, both, but more time in the course. I think just setting up the criteria of what's a good solution, that's a long process and we also need more time in the course. . . . And time for myself, definitely. I think I'm always looking for that. Because to find the best, the question that will bring out all the levels in everybody, takes a lot of time. They're hard to find, and maybe I try to start too big and should start a little bit at a time. (Interview transcript, April 23, 1998)

She also finds that the time that it takes to "cover the curriculum" and teach the necessary skills does not allow for much time for problem solving and developing an inquiry mode in mathematics.

Time, trying to find that fine line, or trying to find the medium between teaching the skills. There are so many skills that they need to learn in grade nine in the curriculum and I spend so much of my time doing little examples of all the different scenarios and powers or in the equations and I think we spend so much time making sure that they have those and put the other on the back burners, the activities that are rich learning tasks, that I find it very frustrating. (Interview transcript, April 23, 1998)

Gwen also faces the dilemma of how much guidance she should give students in problem solving activities. She discussed this specifically with reference to her patio building problem solving activity:

I guess there were a couple of things I thought about like: whether or not to give them more direction or to see how much they could do on their own? . . . I liked the activity but maybe there could have been more open-ended things. The first day wasn't very open-ended. It was basically just getting the generalizations. Later each group had different ways of presenting the data and that was neat. I really wanted a variety
of things occurring to let them demonstrate their creativity. (Interview transcript, May 25, 1998)

Gwen also had difficulty finding exemplars of activities, assessment strategies and assessment tools. She finds that many of the rubrics available are not specific enough:

The rubrics are a real difficulty. Some of the problem solving rubrics that I have seen have descriptors such as "can do this question with minimal assistance". Well, I don't know what minimal assistance is. Should students not ask the teacher for help? That's a question I have difficulty with. (Interview transcript, April 23, 1998)

Gwen also feels that there will be difficulties with full-scale implementation of authentic assessment as she has noticed a variety of interpretations and inconsistencies among teachers in her department. Part of this she sees as a lack of understanding by some of the nature of an "outcome"

I don't think we'll even look at the outcome. I don't think, I think a lot of people interpreted outcome as 'can they multiply powers, can they do everything that they could do before that they were getting a mark for', they can't do, they can't handle negative exponents, then they're below level, well, what is it that they, I think it's not looking at the whole picture, the outcomes are more. (Interview transcript, April 23, 1998)

Gwen is also concerned about inconsistency that may occur between teachers in evaluating students. She notices this inconsistency among teachers who are using the rating scales of the grade nine report card:

There's a lot of inconsistency within the department. There are a lot of people teaching grade nine and I think many of them aren't familiar with the levels. So "E" is meant to be above and beyond the grade level expectation now, yet a lot of people interpret "E" as an excellent student. So everyone's interpretation is very different, and I think it's founded more on a mark scale in their minds than it is on what the scale actually refers to. (Interview transcript, April 23, 1998)
4.1.6 Summary

Gwen uses authentic assessment activities because she believes that they better reflect the process of learning, encourage the development of higher order thinking skills, and enhance students' self-confidence and self-reflection. Her use of authentic assessment activities is most extensive in grade nine where traditional lessons and assessments supplement group work and problem solving. Gwen also uses portfolios, and reflective questions on tests to encourage students to think about, and develop greater responsibility for their own learning. She finds that the use of a non-traditional grade nine report card fosters her use of authentic assessment because the authentic assessment scoring smoothly adapts to a level on a rating scale yet is difficult to translate to a percentage mark. In higher grades, where percentage marks are reported, she employs standard testing and teaching practices but occasionally includes a performance based assessment or open-ended problem solving activity. She finds that the vast amount of content that must be covered in senior courses does not allow much time for problem solving activities.

Many of Gwen’s activities are created from ideas gathered from colleagues or resources and then adapted for her own use. Gwen’s major frustration is the lack of time to create and adapt problem solving and reflective instructional activities, and their accompanying assessment. She is also bothered by her colleagues’ lack of interest in attempting to use authentic assessment activities which for her, creates issues of consistency in instruction and evaluation. For Gwen, working with others to develop her expertise, is critical.
4.2 The Case of Julia

Julia was completing her fourth year of teaching when this study was started. All of her teaching experience has been at Glenview, and Gwen has been one of her colleagues throughout her teaching career. Julia wanted to be a mathematics teacher since she was in high school. One of her parents is a mathematics teacher so the territory was never foreign to her. She was an active mathematics student in high school, participating in mathematics contests and giving up time to be a peer tutor in mathematics. She mentioned that she especially liked the problem solving aspect of mathematics and asked why she liked math, she replied:

I got it. It was just very obvious to me. It just made sense and I liked figuring things out. I liked having a problem that I had to sit down and battle with it because I knew that eventually, somehow, I would get it even if it took me 10 pieces of paper and trying all kinds of different things. I would eventually find some way of figuring it out. (Interview transcript, May 2, 1998)

Julia studied Mathematics in university and obtained an Honours Mathematics degree, teaching qualifications in both Mathematics and Physics and has recently obtained her Mathematics Honour Specialist Qualifications.

4.2.1 Julia’s View of Mathematics and Assessment

Julia sees mathematics as a problem solving activity and wants the students to focus on the process of mathematics as well as the content of mathematics. One of her goals as a mathematics teacher is to increase students’ understanding of mathematics. I asked Julia to describe her goals as a mathematics teacher and she reported:

Obviously I hope to give them [the students] as much of an understanding of what I’ve taught that year. On top of that, more
confidence in math. I find that is something that I am always trying to encourage in students, especially in the younger grades. There are students who think "I just can't do math" and this is especially visible with students who take a general level math course. Yet it is important for them to understand that math is important and that they can do it. Some may do it differently than others but they all can get through it eventually. I try more and more to get them to think and understand but that seems to be an ongoing difficult battle. It's getting them to look at something and to dive in and just start trying things. I think that's also a matter of confidence too. I think that kids just think "Oh, I can't do it." I am trying to get them to just grab a scrap piece of paper and just write down a whole bunch of stuff. Try it. Fiddle around with it. I'll help you a bit but show me that you've tried something before you ask for help. (Interview transcript, May 2, 1998)

She also expresses her frustration at students' unwillingness to take a chance and jump into a problem:

I try more and more to get them to think but that seems to be an ongoing difficult battle. It's getting them to look at something and to get them to dive in and just start trying things and I think that's part of the confidence thing too. I think that kids just think "Oh, I can't do it." I am trying to get them to just grab a scrap piece of paper and just write down a whole bunch of stuff. Try it. Fiddle around with it. I'll help you a bit but show me that you've tried something before you ask for help. (Interview Transcript, May 2, 1998)

She stresses the importance of students recognizing that there can be more than one way to solve a problem and that students do not always need to solve the problem the same way that the teacher does. She also believes in helping students take ownership for their own learning.

I think the main reason for most of the activities I do is for them to think on their own or with their friends but at least without me. They need to sort things out in their own heads. . . . I mean if you have them mark their notebook, for instance, they come up with their own criteria. It's better than my marking their notebook and they perceive that if I think it's bad then it's bad. They need to learn to self-evaluate. They need to think more about their own learning and they need to think about math without me telling them what to think. I think it really does help them learn more about what they should be working on and what's'
important - to me anyway. I mean you are still forcing your ideals on
them to some degree but . . . it’s kind of a combination of all of those
things that you mentioned. I try to encourage communication but I
don’t do it all the time. For instance, many of those enhanced kids are
great at getting the answer but not so great at communicating how they
got to the answer so for them that is something they need to work on.
(Interview Transcript, January 14, 1999)

4.2.2 Julia’s Use of Authentic Assessment

Julia uses authentic assessment to help to develop students’ responsibility
towards their own learning, to increase their communication of mathematics and to
help them examine the process of mathematics. Also, authentic assessment suits
many of the types of activities that she initiates with her students:

Usually I come up with the instructional activity first and then think
about how I want to assess it. I think overall I am trying to change the
types of activities I am doing. Not just because of the assessment but
because of what I am trying to do in the class. (Interview Transcript,
January 14, 1999)

She seems to feel that authentic assessment gives students feedback that enhances
their learning.

Sometimes I like to do it [an authentic assessment activity] as a follow-
up maybe to try to tie in a bunch of different concepts, maybe not even
just from that unit but from other units and see whether they can pull
things together. A lot of it is just having them extend their thinking. I
mean something as simple as just that exercise on rational numbers that I
did. I am looking to see whether they really got it or whether they just
know the rules. So it is kind of just checking things on a different level
that you don’t do with the normal type of assessment. (Interview
Transcript, January 14, 1999)

She also believes that authentic assessment is a more realistic assessment situation
than paper and pencil tests and is less stressful for students:

. . . Students just get so stressed out [with traditional assessment] and it
seems to put so much pressure on that particular moment. It doesn’t
necessarily give you a good idea of how the student is doing or how they understand things. And it also only allows you to ask certain types of questions because you are trying to cover a whole unit of material in one period and you can only have questions that will take just a few minutes and can’t ask things that they have to think about a little longer and play around with and experiment with. I like to give them those kind of questions. So I guess that’s more from a student’s perspective. It really creates somewhat less stressful situations. (Interview Transcript, May 2, 1998)

Julia has tried a wide variety of authentic assessment tools and uses these tools alongside the more traditional assessment practices of tests at the end of a unit, frequent quizzes, and final exams. Her assessment techniques include journals, use of rubrics for evaluating problem solving, self- and peer-evaluation, and student goal-setting. The following is her discussion of her experiences with using journals in her grade nine classes:

Two years ago I tried journals and I kind of went overboard on them. I didn’t do them this year because I kind of overdid them that year. I think that I need to figure out a way that I can incorporate writing without giving them a journal entry every day. Sometimes it was a writing exercise, sometimes it was a problem. Sometimes it was a question like “How do you feel about something?” or describe something in words, or sometimes it would be a very challenging problem that they could work on for a while. That way they kept it all in a separate book so we didn’t give a particular mark to the problem solving activity. I would write comments on it, make suggestions and that type of thing. (Interview Transcript, May 2, 1998)

I asked Julia why she used journals and she responded:

It really had me see a different level of the students; how they feel about math. It made them talk about math a little bit more, not verbally but in their writing. I think it was more to help them rather than me. I wanted them to think through things and to write things down. Some of my students that normally didn’t like math, loved the journals. Perhaps they were more artistic and more expressive. When I started incorporating journals, especially the written exercises, I found a lot of students who were more inclined to the languages looked forward to coming into class and writing for a while instead of what they thought
was "math, real math". So, it seemed to encourage a different group of students as well. And I didn’t really think about or plan that but it happened. (Interview Transcript, May 2, 1998)

Again, we see her valuing mathematical communication and building self-confidence and positive feelings about mathematics. The journals were also a forum for Julia to give feedback to students through her responses to their journals:

I mean if the student had written about how they felt did on their test or something and if it sounded that they needed some encouragement or guidance in ways that they could improve things. Sometimes they would ask me questions in their journal, or tell me that they didn’t understand a particular question. “I didn’t understand how to do this.” I would write a response back to them in it. Sometimes the student took a neat approach on a question then I would say that’s a neat idea, a neat way of solving this. (Interview Transcript, May 2, 1998)

Julia also uses other forms of self-evaluation in her grade nine class and in her more senior classes. In grade nine she uses self-evaluation in assessing students’ notebooks.

With the notebooks, starting off right at the beginning, we talk about what would make up a good notebook. Then we’ve got the sheet with all of the things that we discussed as a group as to what should be in a good notebook. We put that at the front of the notebook. Then every time they hand in their notebook, I tell them the week before that their notebooks are going to be collected, they should look through them to make sure that things are in order. And they go through and they check off the list first of all just to make sure. This is sort of their way of saying “Okay am I going to worry about this or do anything to fix things up?”. So, I usually give them about a week to sort of get them in order and then they hand it in and then I mark it. Generally their mark is pretty close to mine. . . (Interview Transcript, May 2, 1998)

Julia uses self-evaluation with her grade twelve students as well:

I had my grade twelve class do a self-evaluation as well. They just handed in a pretty major assignment and I had them do a self-evaluation because one part of their mark is on organization, presentation of their solution, use of time management - both in-class time and outside time. I can evaluate them on use of class time but they could also evaluate
themselves on use of class time as well as time outside of class. . . . It will be interesting to see their perception of how they are doing things. (Interview Transcript, May 2, 1998)

Julia uses this method of discussing evaluation criteria before assessment takes place when she assigns projects and problem solving exercises as well. She describes the procedure with grade nine:

And I do the same when I give them [grade nine students] projects. I give them an assignment and when I give it out to them, I explain the assignment to them and I talk about what the expectations of that assignment are. We discuss what they think would make a good assignment, and not such a good assignment, and then once they have finished the assignment they complete the evaluation based on what we discussed. (Interview Transcript, May 2, 1998)

Julia finds that students take the assignments and projects more seriously when she discusses the assignment and its assessment at the outset.

. . . when I do that, I always get a larger portion of assignments well done. Always. And often students will surprise me because they have thought before they did it about what needs to be done and they kind of understand the magnitude of it. Sometimes I find they must just figure they can do the problem at lunch and don't really care but when I talk about it with them that way then they seem to think that it really is important. They seem to work that much harder on it. They worry more about the little details of it. (Interview Transcript, May 2, 1998)

Julia also uses other self-assessment strategies with her grade twelve class to develop her students' self-reflection through goal-setting.

I tried to talk to my grade twelve's about OAC being, well, it doesn't stand on its own. You have to know the grade twelve stuff for OAC. I have them fill out goal sheets at the beginning of the year and one of the questions is "Are you planning on taking any OAC math?". I want them to start looking ahead so then based on their response to their future goals, I ask them what they would like to achieve in this course. And then I have them write down what they are willing to do to achieve that. And then if these things don't work, what else would you be willing to do. I kept a copy myself and I gave them back a copy and every once in a while I tell them to go back and look at it but I wish I had them go
back and write about it, write more about it, think about what they are doing, think about what goal they set and perhaps revise their goal if it is necessary. I should have used that in all of my courses but at the time it was just something I thought about doing. I hear them talking, "Oh, I am almost at my goal" and it surprises me. For some of them it is still motivating but I didn’t do enough with it. I could have done a lot more. (Interview Transcript, May 2, 1998)

Julia feels that this goal-setting also helps students develop responsibility for their own learning.

I think that is more what we need to get to with the senior students is a lot more self-directed stuff, like goal-setting. . . Maybe they would take a little more ownership of it. I don’t know. (Interview Transcript, May 2, 1998)

4.2.3 Examples of Assessment/ Problem-Solving Activities

One activity that Julia has used with her grade nine class was the scale drawing assignment [Appendix C - 3]. Julia reviewed the assessment criteria before the students began on the assignment. She discussed the idea of a rubric with the students through the use of an overhead and the students gave her great input (Julia’s Assessment Log, May 6, 1998).

. . . I usually write down on the overhead with them what would really make a good assignment and some of the things that would tend to make a satisfactory kind of assignment and what would be something that would be considered to be not such a great assignment. We will write down together as a group some things to look for. We just did one on scale drawings. They had to do scale drawings of their room. So you know a really good assignment would have all the calculations written out and they would be correct and it would be organized and maybe there would be extra detail added in. They came up with all of those types of criteria and really, if we have discussed it that way then I tend to stick to their comments and suggestions as I am marking it as well. (Interview Transcript, May 2, 1998)
Julia was surprised at the good choice of descriptors for the achievement of the criteria that the students gave even though Julia claimed that they hadn’t had much prior discussion about this. Julia noticed that many students came in for help with this assignment and she wondered whether discussing the expectations with them before the assignment helped the students realize the importance of doing a good job (Julia’s Assessment Log, May 6, 1998). I then asked Julia specifically how she marked the assignment and she replied:

I have been using a general impression in the past but more recently I have tried a rubric for the scale diagram project. We set up Level 1, Level 2, we came up with words that maybe they could deal with like "Wow" or "Pretty Neat" and then underneath each level we wrote down all of the things that we thought would be criteria for each of those levels. And then I didn’t hand that out to them. I just put it back up on the overhead and they wrote down on the back of the assignment which level they thought they had completed and why they thought they had completed it. It seemed like they put a lot of energy into that assignment. I have students that generally hand in crumpled work or hand in not such a great effort but I saw them put lots of effort into it. I still had a couple who did what they always do - a little bit of work on a little piece of paper with no calculations shown or anything. (Interview transcript, June 15, 1998)

Julia was convinced that the students put more effort into their work because of the emphasis and type of assessment that was taking place:

I think they put more effort into it because of the evaluation things. I noticed that on the next day, I had more students in for extra help than I have seen in the whole year. They suddenly seemed to think that it was really important and they kind of had to make sure that they understood how to do it. Other times I have given them an assignment and they haven’t gone through that kind of a process and they would say “Oh, I didn’t do it”, “I didn’t really get that” and I would ask “Why didn’t you come in?” and they would respond “Oh, I didn’t really think about it.” I was amazed how many students came in for help and they had measured their room before they came to class the next day and were much more organized going through the process. It seemed to work. (Interview transcript, June 15, 1998)
Julia used a version of “Patio Project” with her grade 9 classes. The group project was done over three days and she used several methods of assessment: observation, self-evaluation and an interview. While students worked, she observed and recorded her observation on a sheet that listed each group. She made notes on how the students worked as a group and the types of mathematics that they were doing. She notes in her Assessment Log that:

This worked well and allowed me to remember different aspects of how the groups worked, especially since it was over three different days. I used this to make some comments on my grade 9 recording sheets and on the sheets that I returned to each group. (May 30, 1998)

Each group completed a self-evaluation checklist on how well their group worked together. They also wrote a paragraph on the groups' strengths and weaknesses. Julia notes that “many of the students had trouble getting the work done because they did not delegate. This group evaluation then allowed them to think about how they could have done things differently” (Assessment Log, May 30, 1998). Julia’s interview with the group was preceded by each group being given a list of questions that she would be discussing with them. She sat with each group and discussed their results and asked follow-up questions. She notes in her Assessment Log:

I really liked this! I was going to have each group present their work but this can get boring and they just start repeating one another. Interviewing them allowed me to get a much better feel for what they had learned, and was not as stressful for them! (May 30, 1998)

I observed Julia in a grade nine class in what she described as a normal class doing things she usually does. She mentioned that, during our other observation, she
felt as though she had to invite me to see something special but she realizes that perhaps I should just observe a routine class (Field notes, November 25, 1998). This grade nine class would be doing a short group activity. She had previously tried the activity with her enhanced grade nine class and was very surprised at the depth of the results. She thought that this should prompt her to try it with her regular destreamed grade nine mathematics class. My field notes describe the class:

There were 20 students in the class on that day and the students sat in pairs. She instructed them to listen first and then to pick their partners. She wrote the statement on the board: "Explain to me in as many ways as possible what 1/2 + 1/3 =" She then expanded by saying that they could use math symbols, pictures, real world examples such as oranges, chocolate bars or pizza, or words. They were told to think about a previous activity when they had to explain how to add integers to a younger person.

One student asked: "Are we explaining what the answer is or how to get it?" Julia answered that they were doing both. She mentioned that there were two things that she would be looking at and these relate to their report card. "The first is the first thing on their report card: Numeracy" and then she wrote the levels that appeared on the report card: M, S, V, E" and the other thing was Creativity. She mentioned that sometimes she is questioned about whether there is creativity in math and this was a good example to show creativity since they should come up with creative and varied ways to explain this. One student asked "Does this reflect our whole year of creativity?" and Julia responded by having them recall other instances when they had the opportunity to show creativity.

Some students then moved around to sit together. Others just sat where they were. Julia encouraged "All right, let's go!" Many of the pairs sat back and started discussing some of their ideas. Most students started with either 1/2 + 1/3 or drawings of fractions of pies shaded in. Julia stopped the students at one point and announced "You don't have to use all of the ways I wrote on the board." Julia circulated and added comments as groups worked. "Whatever you choose to do, make sure you explain it clearly", Julia told one group. In the beginning, some students seemed to have difficulty with the meaning of "real world" examples. Two boys drew planets and divided them into parts. Two girls wondered if they could use smarties and divide the pack. Another
group used the number of people in a room and stated that “1/2 of the people think one thing and 1/3 think another. What fraction of the room is that?”.

Towards the end of the period, Julia stopped the students and said that since they were working so well on this and had more to think about they could finish the assignment for homework. They were to write up some of their solutions in a neater format. (Field Notes, November 25, 1998)

Julia and I discussed the activity after she had collected and assessed the student responses. She thought that the enhanced class had understood the task better than the destreamed class and that for both classes it took some time for them to understand that they were not just to show the answer but to explain or demonstrate how fractions are added together. She also noticed that having students take the problem home made a big difference.

... Taking it [the assignment] home made a big difference. Maybe they talked it over with people. Maybe they just thought about it more. While they were working on it in class, it looked pretty dismal but once I took it in it looked like maybe there was a handful of kids who really, really understood it and took it to its fullest extent and came up with lots of examples. (Interview transcript, December 5, 1998)

I asked Julia how she assessed their work on this activity and she described:

I sorted through them and . . . separated them into different piles in terms of where they were at and how they explained things and how many different explanations they gave and how much it looked like they really understood the concept. (Interview transcript, December 5, 1998)

Julia then explained that she gave them a “mark” based on the scale that is used on the report card which has categories such as marginal, satisfactory, very good, and excellent. I asked her what she might do differently or what she had learned from doing the assignment with the students and she mentioned that she wondered
whether she should do more diagramming when introducing fractions or rational numbers at the grade 9 level. She had started the unit assuming that they already had concrete concepts of operations with fractions but perhaps she needed to review that. She also questioned whether reviewing these notions would be prompts for the activity and she questioned how much prompting is appropriate in open-ended problem setting.

Julia reflected that she had "difficulty thinking about incorporating authentic assessment into the grade twelve course. We seem to put a good effort inputting it into the grade nine course but then we stop there" (Assessment Log, May 8, 1998). One of her goals appeared to try to incorporate more open-ended problem solving in the grade twelve course. Julia was fortunate to have the opportunity to work with grade twelve's throughout this study since she had a grade twelve class during the spring of the initial stages of this project, another grade twelve class during summer school, and yet another during the fall and winter towards the conclusion of the study. She began using self-assessment with her grade twelve class which utilized a checklist of how the students used class time, presented solutions, and put forth effort. She was concerned that:

Too many of them goof around in class and then want help later. I wanted the students to think about what kind of an effort they put forth. I combined their suggestions with my own observations and a certain percentage of their mark was related to this assessment of effort. (Assessment Log, May 21, 1999)

During Julia's summer school grade twelve mathematics course she had decided that she was going to embark on problem solving activities with the students.
This summer school course was designed for students who wanted to move ahead in mathematics as opposed to some of the other summer school courses that were designed for remediation. Julia felt as though the students could handle the challenge. I observed this summer school class during a problem solving session using authentic assessment. The students in the class were fairly keen because they were taking the course to “get ahead” and be able to take OAC courses in their fourth year of high school. Each day’s class was five hours in length with a break in the middle. The problem solving activity was to begin after the break which was when I arrived.

Earlier in the morning, Julia had started the class by returning the assessments of a previous problem solving situation “The Cassette Tape” [Appendix C-1a-c]. Julia mentions that when she did the activity the students had worked in groups for approximately 90 minutes. The students worked very hard and there was a great deal of discussion. However, she felt that the students found the problem difficult, and perhaps too open-ended as a first problem solving activity. The students wanted numbers to work with to solve the problem and they had difficulty deciding how to draw a graph without numbers. They did not envision setting arbitrary numbers or thinking of the cassette tape as a whole and recording fractions of it. She mentions that “I think we need to spend more time working on the skill of sketching graphs based on real life situations without having specific numbers” (Assessment Log, July 17, 1998). However, she was surprised at the students’ perseverance and attributed
much of the perseverance to the mathematical strength of the students in this particular class.

As Julia returned the papers, she reviewed with the students that the assessment was based on an analytic scoring scale comprised of the categories "Understanding the problem", "Planning a solution" and "Getting/presenting an answer" [Appendix C-1c]. Julia had been surprised at how well they had done on the activity and Julia reported that they were also surprised because although they were given the evaluation criteria ahead of time, they seemed not to believe that the understanding and planning of the solution would be valued as importantly as the solution itself. She also told them that they would be doing another problem solving activity later in the class.

After the break, Julia led a discussion of the evaluation criteria to be used for this new problem, "The Camping Problem" [Appendix C-2a-c]. Julia displayed an overhead of the criteria [Appendix C-2c] and read through this with the class. She discussed each of the categories of process, communication and answers separately explaining what each of these meant. The discussion took several minutes. Students then broke into groups of two or three. She distributed the problem, one per group, and told the class that there were materials at the front of the room that they could use if they wanted to. The materials included scissors, tape, string and grid paper. In this problem students are told that they are to map out a campsite of greatest area when they are given the length of rope that they can use as a boundary and flagposts to use at the corners.
Most of the groups were on task and Julia circulated around the room. Some groups read the problem orally, others went up to the front of the room to get string and scissors and immediately begin modeling the problem using their pencils as posts. Others picked up grid paper and started drawing different scenarios. Some began creating formulas and were using trial and error, substituting values, and calculating the area. One student was busy looking through the index in the textbook, perhaps for some insight. Some groups began setting up charts. The students seemed to begin solving the problem in many different ways. However, in general, there was much mathematical discussion. I noticed that she never interrupted the whole class to clarify the problem but rather would answer questions as she circulated. She gave very little information as she circulated and very few hints. She allowed groups to answer one another’s questions. All groups appeared very task oriented and seemed to work well together. The students worked for approximately 35 minutes. If a group finished early, Julia gave them the challenge of seeking another geometric shape that might give them even more area. The students then tried triangles, trapezoids, or circles rather than rectangles and had a good discussion about whether they needed to use trigonometry to solve the problem and whether they should classify the triangles they experimented with. Another group that was given the same challenge mentioned that perhaps a circle would give the greatest area. I noticed that Julia did not respond at all even though she recognized that the circle would give the greatest area. She allowed them to continue to discover this for themselves. As the class was ending, Julia asked them to submit their solutions.
Julia and I talked after she had reviewed their responses to the problem. She seemed to be perplexed as to how she would assess them (even though she had the assessment criteria “up front”). When faced with the submissions, she was concerned with distinguishing one level from the other. She noticed that very few students had used an algebraic approach and then questioned whether an algebraic approach should be deemed better than a chart or written solution. Eventually she developed a system for assessing by first sorting the solutions into piles and determining more detailed criteria through recording her thoughts in sorting the submissions.

4.2.4 Support for Authentic Assessment

Julia finds that working with someone has great advantages. She claims that it is important to have someone to discuss ideas with because Julia finds that, through discussion, her ideas are both reinforced and developed further.

In terms of coming up with things[to help me]? I guess mainly just resources, probably it’s people. Just talking to people, or you hear someone come up with something and that starts off an idea. Also, I use other books, textbooks, math books, etc. (Interview Transcript, January 14, 1999)

It is just as important to have the support of a colleague when things may not work well, as it is to have someone with whom to celebrate successes.

Julia finds that the grade nine report card has encouraged her to use authentic assessment activities:

From a teaching perspective, I do a lot with the grade nines because of the way the report card is set up. It’s kind of encouraging when you to start working in that direction. I mean, the first year that I started working with that report card, I realized that it is better for the students if we give them a more well-rounded view of who they are rather can
they just answer this type of question about integers or this type of question about algebra. (Interview Transcript, May 2, 1998)

The difficulty emerges as she attempts to move open-ended problem solving activities and authentic assessment through the more senior grades. There she meets up with such stumbling blocks as time constraints and the difficulty of adapting authentic assessment to a percentage grading system.

4.2.5 Problems/ Stumbling Blocks

Julia mentions several obstacles to extending her use of authentic assessment. These include the drive to cover the content of the course, a shortage of time, lack of resources of good problem solving activities, and the difficulty of translating authentic assessment into traditional marks. Like Gwen, Julia felt as though the grade nine program was more activity based while the senior grades were driven by “covering the content.”

In the senior grades we are trying to just get through the course and I am finding that I try to do more activities and stuff in grade 9. I don’t try to do that as much in the senior level courses because I don’t have time. (Interview Transcript, May 2, 1998)

Julia finds it difficult to translate authentic assessment into marks. She has used observation, open-ended problem solving, and developed rubrics in some of her senior classes. She uses these methods in an attempt to increase students’ understanding of mathematics through problem solving scenarios, but she finds it difficult to translate this assessment into a traditional reporting format.

I am doing more now in my computer classes. In fact I have tried to do a little more observation in that class but then I ask myself “What do I do with that information?” The grade 9 report card lends itself to using that type of assessment. It feels like you are taking that information and
using it in a productive way. There is a place on the report card to say that they are having difficulty with organizational skills or other things. You know that you can take a lot of the stuff from the assessment you do and apply it. There is room for feedback. But I find that when you are just giving the student a mark, and I am doing an observation of how they are working on a computer or working in groups or stuff, how do I apply that to a grade 12 student’s mark? We don’t have a section for that type of thing. We have a percentage but that doesn’t provide them with useful feedback for themselves. (Interview Transcript, May 2, 1998)

Another difficulty that Julia found in using authentic assessment was balancing its use within regular classroom routines. In her experiences with using journals, she began by using journals every day in her grade nine class and liked the pattern or routine it created.

In a way I like doing them every day because it worked well for them to have a routine. They knew that they would come into class and we started every class with them. So they would go up and get their journals and sit down and get ready to write so in some ways it was nice because it was a routine for them but it kind of got to be a bit much, they got sick of it. Maybe once a week would be nice or every time you had them on a Friday or the last period of the day, a routine but not such a regular routine. (Interview Transcript, May 2, 1998)

When I asked whether she thought that those activities were still worth doing in grade twelve, Julia responded:

Yes, by all means. Because I think that they [the students] have lost that thinking, that enthusiasm, that thinking about what they are doing. I find that a lot of the senior students start to really get to the point where they are just memorizing how to do things rather than thinking about what they are doing. I mean I tried this year and I didn’t think about it that much but this could have been a much bigger idea, something I could have done a lot with. (Interview Transcript, May 2, 1998)

In comparing grade twelve students to grade nine students, it is important to note that grade twelve students are beginning to focus on entrance to university. For them, “marks” are the “ticket” that they need to obtain admission to the university
programs of their choice. Therefore, the students tend to focus on what they need to do to obtain the highest possible mark.

4.2.6 Summary

Julia would like her students to understand mathematics rather than view mathematics as a set of memorized algorithms. She values risk-taking and encourages self-confidence in setting open-ended problems for her students to explore. Julia uses authentic assessment activities at all grade levels, however, her greatest use is in grade nine. She is using authentic assessment activities in conjunction with traditional lessons and assessments.

Julia creates many of her own open-ended problems and accompanying assessment. She is willing to try new ideas in the classroom and easily adapts and improves these ideas through experience. Julia struggles with the balance between open-ended problem solving and covering the content of the course. She is frustrated with the shortage of time within the course to pursue activities to deepen students' understanding and also with the shortage of time to develop appropriate activities and materials.

However, Julia has a vision of a curriculum that could incorporate the teaching of mathematical skills within a problem solving setting. She also recognizes that the time commitment to develop such a curriculum makes it difficult for a busy classroom teacher to create. She also recognizes that to effect such a curriculum requires that
both the curriculum developer and the individual teacher have a great deal of professional expertise.
4.3 The Case of Dave

Dave is an experienced teacher who was in his first year as Head of the Mathematics Department at his school during this study. He has been very involved in a local chapter of the provincial mathematics educators association. He is also a frequent conference presenter both within the school board and at the provincial level. Dave has been teaching for 20 years with a five year break in the middle of his teaching career when he was in business. His teaching experience includes both secondary school and community college in mathematics and computer science. He is also currently teaching two business courses in finance. During his financial planning business venture he taught some courses in financial planning to potential franchisees.

I was curious as to why Dave left teaching to go into business, why he then returned and also what impact the experience had on the classroom. Dave explained his reasons for wanting to go into business:

I wanted to prove to myself that I could do something else besides teach. I found I could but I also found out that there were aspects of business that I didn’t particularly like, like the hours. I was in the office from 9 in the morning until midnight most evenings. My son was growing up and I wasn’t seeing him at all. He was asleep when I left for the office and asleep when I came home. I also found out that I didn’t particularly like being the boss. I had to hire and fire people and stuff like that and I didn’t really enjoy it. I mean, I didn’t leave teaching because I hated it or anything I just wanted to see if I could do something else. I’m glad that I tried it and now I know the answer. Yes, I can do something else. (Interview Transcript, October 1, 1998)

I asked whether this experience changed Dave’s perspective on teaching and he responded that it definitely had.

I noticed when I first came back that a lot of the things that people thought were very important in teaching were all trivial. Oh, it’s really
important that we have this test on this day. Well, why? Why not the day before, or the day after? As long as the kids know the material it doesn't matter what day the test is. Who cares? But some are very, very rigid in their instruction. But anyway, it was a really good experience and it certainly has allowed me to delve more into the applications of mathematics. I was always interested in applications but I got to see some real-life stuff. . . . Now, I can say, yes, when I did this, I actually used this. So, when I teach the Business 12 Math, I say to kids that 80% of our business was based on what we learn in this course. Trust me, somebody really does use this stuff. (Interview Transcript, October 1, 1998)

Dave's educational background includes a Bachelor of Mathematics degree from Waterloo in Applied Mathematics. He mentioned that once he graduated he was "disappointed because I found you couldn't apply it to anything". He also has a Bachelor of Education Degree, a Masters Degree in Mathematics and a Masters of Business Administration Degree. Both Masters degrees where obtained while he was teaching. He is also registered as a financial planner.

Dave is at a large suburban secondary school called Bromsgrove Secondary School. Although his position of Department Head is new, he has been at the school for seven years. Dave describes the school:

We have 1764 students this year which is roughly about 100 odd over what we are staffed for. It is very sort of cosmopolitan mix - ethnically.. . . Probably about 70% are in advanced level courses. That may not be the correct mix but that is what they have chosen. If I was guessing I would say that about 50% of the population shouldn't be taking advanced math. (Interview Transcript, October 1, 1998)

Dave would consider the school to be very traditional and the previous department head and assistant heads as very traditional mathematics teachers. He explains that:

That is the reason why I spent 7 years in a portable - that way I could try stuff with no friction. Certainly, originally when I came I thought I would be a disciple of change but I had that pounded out of me fairly quickly and so I basically conceded that and said I will do what I want.
You guys do what you want and that worked great until I became the Head. (Interview Transcript, October 1, 1998)

Dave’s view of mathematics education is very different from the previous Department Head’s traditional perspective.

4.3.1 Dave’s View of Mathematics and Assessment

Dave suggests that “math is a subject that we learn by doing”. He also believes that students should see connections between mathematics and the “real world” and that mathematics takes on meaning when it is applied. He also encourages the appropriate use of technology, such as computers and graphing calculators, in mathematics investigations.

Dave is very adamant that teachers should not just be teaching examples of types of questions and then assigning several more of the same as homework.

I don’t think it is a subject that you should learn by doing exactly the same thing that the teacher does at the blackboard. I think that is mainly how it is taught here. “Here do 45 more of what I just did, except the numbers will be different.” There is very much a traditional focus here on algorithmic procedures and the kind of “fill up the sack” view. People seem to think “We have this many days, we have this much content”. And that is a very difficult concept for me to live with. I think in general with mathematics we have done a great job of pounding any of the joy out of it. When a kid is here in grade 9 he has lost the feeling that in math you find out stuff as opposed to just confirming that yes, the teacher can really complete the square and now so can I because I have done so many of them. (Interview Transcript, October 1, 1998)

Dave gave several examples of what he did not think should be happening in a mathematics class and I wanted to explore his vision of what mathematics class should be doing. He believed that various instructional strategies should be used.

His view of a mathematics class:
What wouldn’t be going on a lot of the time is the “sage on the stage” routine. I am much more a fan of cooperative learning types of situations. But I also think that when students are working in groups, there have to be a few gems of knowledge thrown out first. I think you need someone [as a teacher] who is interested in mathematics to be there to offer starting points, a way around a stumbling blocks, offer an alternative to something that looks very tedious. (Interview Transcript, October 1, 1998)

Dave uses co-operative learning group work as one of his teaching strategies to enable students to explore mathematical concepts. He does not believe that mathematics is simply memorizing algorithmic processes.

I do believe that the vast majority of mathematics does not require highly sophisticated algorithmic things to accomplish what you want to accomplish. I’m not a fan of a lot of the curriculum that requires kids to memorize stuff - special triangles or memorize this type of question because they all look like this. Well, most of the world doesn’t all look like that. And I’m not saying you shouldn’t try to classify problems based on your prior knowledge and so on. (Interview Transcript, October 1, 1998)

And yet he finds that many of his colleagues stress these algorithmic processes:

I find that shows up all over the place. I have kids in Finite say “Well can we use such and such a thing?” I say “Well sure, it is never wrong to use what you know.” And they say well that’s not true of Mr. So and So’s class. I have to do it this way or get a zero.” (Focus Group Interview, November 4, 1998)

Dave believes in showing students the applications of mathematics, or mathematics in context and he stresses an active approach.

You can’t always do real things with it [math] but I think as much as possible we have to come close. If I am going to do the parabola for three months in a grade 10 course then surely I hope I am going to do a lot of throwing balls up in the air or experiments where I get parabolic data - yet, there’s not a whole lot. (Interview Transcript, October 1, 1998)
He also stresses a strong problem solving model and believes that students should be encouraged to take risks and test out different solutions.

Maybe we should have a problem solving rubric to say - what have we got, what do we have to find, what are ways to try to find this. Those kinds of things. (Interview Transcript, October 1, 1998)

Dave advocates the use of technology in his classroom by creating problems that encourage the use of the graphing calculators or computers which he makes available to the students. Dave maintains that he uses group work, problem solving, and authentic assessment activities such as journals, rubrics and peer assessment. However, he also states that much of the time he is a fairly traditional teacher.

Now, I'm also not saying that I do that all the time but I try. I think a lot of what I teach is traditional. But as much as possible I try to incorporate cooperative learning. As much as I can, with the time I've got and the energy I've got. I try to incorporate more cooperative types of things - whether it's homework groups to take up homework or whether it's group warm-up kinds of things to deduce something or whether it's a two class experiment done in groups followed by some type of analysis. (Interview Transcript, October 1, 1998)

4.3.2 Dave’s Use of Authentic Assessment

Dave combines traditional forms of assessment, such as tests, with the use of journals, group problem solving, peer assessment and rubrics. He also has investigated alternative examination methods to varying degrees. Dave has employed many of these techniques for quite some time. However, other strategies, such as his use and development of rubrics, are just evolving.

Dave encourages co-operative learning in his classroom and works on developing strategies to assess group work or the product of group (or pair) work.
Yes, typically I evaluate group work in a couple of ways - observation, but I also often will use peer assessment or self-assessment or some combination thereof would be more likely. I also evaluate group product and one of the things I found works not badly is to have kind of a random presentation so that if there is 4 people in the group and they are supposed to tackle these 6 questions or however long it is going to take us to do all this stuff. I tell them in advance. At the end of all this I will pick somebody randomly from the group. I will pick a problem and that person will get a chance to explain that problem and its solution to the rest of the class. (Interview Transcript, October 1, 1998)

Dave also uses groups for students to review questions they may have had about their previous night’s homework.

I use homework groups a lot to take up homework. . . . And one of the things someone suggested is that if you want the kids to talk about solutions and alternate solutions then one way to do that is to put the kids in groups, give them a specified amount of time to go over the homework and then if any group, or rather if everyone is stuck on something then they call me or bring it to me and then we kick it around with me as part of the resource. . . . The up side of this is that it is really positive for a lot of kids. It demonstrates that you value the alternative solution, not just the answer. The kid who is too shy to ask in class is almost forced to ask in the group. And the kid who regularly doesn’t do his homework, well, it shows really fast in the group. There is some peer pressure, not directly necessarily. I know I’ve had kids say to me “Since we have homework groups, I have to try my homework every night because everybody else has.” (Interview Transcript, October 1, 1999)

Although Dave makes extensive use of group work, during our first interview, Dave talked of the difficulty of assessing group work because he felt that it was fairly subjective.

I do a fair bit of stuff in pairs as well. So, I assess [work] from the pair. Some kind of product whether it is a written solution or an explanation. Maybe one of the pair gets up and explains what they did. But again, for most of that I kind of sit back and say “Well, yeah, it looks like about a 3.” You know that kind of thing. Now, occasionally it is a little more transparent. I say, “Look, you’re going to get 10 marks for this exercise and here’s how you get a 10, here’s how you get a 6, here’s how you get a . . . well, hopefully you won’t be aiming for anything lower than that”.


But honestly, I don't do a heck of a lot of that. And I feel guilty that I don't. (Interview Transcript, October 1, 1998)

He continues to discuss this dilemma of having difficulty marking problem solving, presentations or other more open-ended situations. He discusses his feeling that he was being subjective in his assessments:

Evaluation is actually a stumbling block for me. I end up in a lot of things, evaluating on a pretty subjective scale. I mean I may have some things that look like scales but when you come right down to it, I think it is pretty subjective. Part of that is that possibly I am not spending enough time on building a scale Part of it is not having enough samples of what a 3/5 or a 5/5 looks like. (Interview Transcript, October 1, 1998)

However, as the project progressed I discerned through the reading of Dave's Assessment Log Book that there was evidence of an increased use of rubrics and we discussed this during our final interview:

Currently you don't need them [rubrics] for a typical test question. You know, it's right, it's wrong. That's the way it goes. But for the more open-ended kinds of things that we get into, it's really obvious the we need that more. My class had a linear programming problem to do and then they had to give a problem to the rest of the class. I don't hold these up as ideal rubrics but they help. For instance, this interview rubric is really weak but it made marking really easy. (Interview Transcript, February 2, 1999)

The rubric [Appendix D-1] had four levels of achievement across the top and outcomes along the left hand side. Dave's reference to "weak" perhaps referred to his descriptors of the levels which were fairly brief. Dave also showed me a rubric that he had created for group presentations [Appendix D-2]. I noticed that numbers were recorded in the blocks which he later explained represented the group numbers which he recorded in the blocks that described their performance as they presented. This
appeared as a timesaving recording device rather than use a separate copy of the rubric for each group. It seemed manageable. Dave describes its use:

While the groups presented I recorded group numbers. They did this in groups of threes. . . . There was a bank manager and a couple applying for a mortgage and everyone else had left the class. Each group had an interview time. So there was only the group of three and me as the observer. Some of them were really impressive. . . . Most marks were predictable but for instance there was one kid with a mark of 60 or so and her group did a terrific job. You could tell that she obviously liked this particular activity. She is not particularly strong in other more academic assignments. Maybe I hooked her on something. (Interview Transcript, February 2, 1999)

I continued to question Dave and inquired about the appeal of using a rubric. Dave responded:

It makes it easier to mark and when I am finished I feel much more comfortable that the mark is semi-objective rather than totally subjective. . . . I also think that it helps me identify in the activity, exactly what do I expect these kids to do. I think they are great! I want to build a rubric for the technology component of the exam. I want to build a rubric for it and take some of these solutions from this semester's class as exemplars to use with my next 2 Finite classes. And if I share these with the students, then they can help me build the rubric. They can determine what a good solution will look like. (Interview Transcript, February 2, 1999)

Dave further explained that even a fair rubric is better than none at all.

I also found that it is easy to build a mediocre rubric. I mean the shopping [for a mortgage] is a really weak rubric but it did force me to list what I was looking for. The descriptors of the levels are very weak. (Interview Transcript, February 2, 1999)

I wondered whether Dave had been experimenting with rubrics because he was a participant in this project and thought he should try different approaches or whether this would have emerged without the study. Dave responded:

It is not that I just wanted to try them. I was dissatisfied with my methods of evaluating open-ended kinds of things. I have done a fair
amount of open-ended kinds of tasks in the past but I always felt as though I was marking it subjectively out of 5 or 10 or 15. I wasn’t happy with that. (Interview Transcript, February 2, 1999)

His response definitely agreed with his earlier misgivings that his previous method of marking group work made him uneasy.

Dave also uses journals extensively in all of his classes, both junior and senior, and has done so for quite some time. He describes their focus:

We’re just writing and most of the time the journal is a response to 2 questions. One of them is “this week in math” and this is more like their response on how confident they are in whatever we did and lots of times they give me particular topics like. “Most of the stuff this week was okay except for topics like” and then they will tell me or give me an example or a page number or something. Or “I had to work 3 nights and I was late getting to my homework and as a result I’m really lost on whatever”. That’s one aspect of it. The other one is usually a question that I stole from some educational research journal. Or, for instance, I found an article in the chiropractor’s office and it talked about an elementary classroom in which they had the kids respond to various questions such as “When I do well in something I like to be rewarded by” or “My favourite subject in school is _______ because ______.” It’s more those kinds of things. In my point of view it kind of rounds the kid out a bit more than the other. I think they’re both useful. The “this week in math” thing is good because the kid who won’t put their hand up and say “Gee, I don’t know what’s going on here with this.” So I like that a lot. (Interview Transcript, October 1, 1998)

Dave thinks that journals are important to use since they give a voice to the student and recognize the value of the individual.

I don’t envision a problem with journals at any grade level. Because every kid likes to be thought of as a person. At least their opinions counts, or at least are read. (Interview Transcript, February 2, 1999)

Dave has also explored the use of alternative examinations on a limited basis. He is not very enthusiastic about the importance placed on traditional exams and explains his reasoning.
Of course the traditional exam doesn’t fit that at all. But that’s okay with me because I don’t “dig” exams. I think we should do away with them. Now I have voiced that before. People say “Oh, you’re nuts. How can you do away with exams?” There is maybe the tiny argument for doing exams so that when the kid does get to college or university they won’t be in shock. However, there is probably more of an argument to say “Fix the colleges and universities so that they don’t keep doing this. This 3 hour marathon type thing.” But to evaluate other areas that I think I’m teaching like investigation or synthesis or whatever it happens to be. To do it in this time slot, all by yourself, is totally inappropriate. It also of course encourages “You know the answer is five and a half and that’s the way it is and you better do it by my method otherwise you get 0.” (Interview Transcript, October 1, 1998)

An alternative to a formal examination was used at one of Dave’s previous schools in a general level mathematics class. Dave recognized that the students in the class had been instructed using cooperative learning strategies and had been actively involved in their learning through problem solving, projects, investigations, and presentations. He felt that to test the students solely on the content of the course in a very structured manner that was dissimilar to their learning style was an injustice. Therefore he and the other teacher of the course created an alternate style of examination.

I used a group final exam over at Lewisville [Secondary School]. I worked with another teacher on it. We both had grade 9 general level classes and there was no way that they were going to sit through an hour and a half exam. You take the classic general level exam where they are doing fine for a while and then they stop writing. “Okay, that’s enough. I’ve had it with this.” So what we devised was a half hour of a traditional type exam and then in the middle half hour we put them in groups of 3 or 4 and they had these experiments they had to do. One was throwing darts at a dart board, another was something about unit costs - we had cans and juice boxes of various sizes. And then back on their own again, they had to analyze and present the data in one form or another, whether it was graphically or in a chart or whatever. We did it mainly because we didn’t think that they could sit for an hour and a half which was true but the results of that were really, really positive. Part of it was because that whole course we did in groups. I don’t think I ever taught a traditional lesson so why have a traditional exam? (Interview Transcript, October 1, 1998)
More recently, as a Department Head, Dave has required that all of the examinations in his department must have a technology component. One of his reasons for doing this was that he knew that, if the use of graphing calculators and computers was on the final examination, then his department members would be compelled to include a technology component in each course. The technology component of the examination was tested in the classroom setting at a different time than the regular examination setting when the students wrote the rest of the examination.

We gave a portion of the exam in class using technology. With this section, in my Finite class, they had access to the TI-92's. . . . It counted for 10% of their exam mark which meant 3% of their final mark. Every course had a technology component that was done in class. The grade 9 was focused on could you use the scientific calculator? (Interview Transcript, February 2, 1999)

4.3.3 Examples of Assessment/ Problem-Solving Activities

One of Dave’s assessment strategies was a group project on the applications of matrices that he used in his OAC Finite Mathematics class. The title of this project was “Matrix Models and the Real World”. Students received a fifty page booklet that Dave had created that contained several different scenarios covering: Communication Matrices; Power Ratings: Who Has the Best Team?; Population Shifts: Transition Matrices; Traffic Flow Analysis; Electronic Circuit Analysis and Kirchoff’s Laws; Economic Analysis: Leontief Production Models; Secret Codes and Matrices; and the Leslie Matrix Model for Population Growth. Students work in groups for two weeks using “jigsaw” strategy.

In this scenario there are expert groups and there are home groups. A student moves from expert group to home group on cue. Initially, students are put into home groups where they are given a set of
problems. They may or may not work on them initially as a group just to get a feel for what they are like. Then each home group separates and each member joins one member from each of the home groups to form an expert group and works on becoming experts on a particular type of problem. In this case, each expert group took on one type of matrix application. For instance, one group became experts in Secret Codes and Matrices, another in Communication Matrices. Once the students have become experts in their type of application then the home groups meet again and the experts take turns teaching or explaining how to do their particular type of application. The goal is for all students to become experts in every type of matrix application. (Pre-observation interview, November 19, 1998)

I observed the class during their first week of this project. The students had been working in their expert groups and at the stage of my observation they were back in their home groups and were taking turns explaining their particular type of matrix application to the group. When I entered the room they all appeared to be engaged in the activity.

Each group appears to have one of its members working at the side board while the others in the groups are taking notes. In one group, the student explaining the electronic circuit problem demonstrates how to obtain five equations from the circuit diagram. In another group (all girls) there is a lively discussion about the traffic flow problem. One student in a group suggests to the others that “You have to follow the pattern. It’s the key to the whole thing.” Students constantly check their groups understanding of their explanation with phrases such as “Do you understand this?” or “Are you ready for the next step?”

The groups work fairly independently. Dave circulates and prompts when required, using phrases such as “Keep labeling”, “You’re doing great.”, “Remember, that means there are infinite solutions.”, or “Do you have drivers’ licenses? Do you every drive the wrong way on a one way street? Well, maybe that’s a speed of -50.” Sometimes he joins a group for a few minutes by pulling over a large orange chair from the teacher’s desk and sitting down as a group member. When students ask Dave questions, Dave often first starts with “Talk to your group and see what they think.” He mentions to me as an aside that the students will often ask the teacher before discussing the problem with the group. Also, they are accustomed to having answers at the back of the book to check rather than verify the answers with the group. When the students are
really stuck, however, Dave will even go the board to demonstrate a concept to one group or another. (Field Notes, November 19, 1998)

My observation took place during the last period of the day, so I had the fortune of being able to talk to Dave immediately following the class. I asked Dave how he was going to assess this project and he had several different strategies. He suggested a group test, a group presentation, conferencing with each student as a manner of an oral test, and he also mentioned an interview with the student where the student must respond to the question: “Convince me that you know this material.” When I saw Dave several weeks later he described his chosen assessment strategies. He used assessments of group participation, section problems, review problems, a group presentation and a test. He used a rubric to assess each of these items [Appendix D - 3] and he found that this worked very well in assessing the entire project. He felt comfortable with the marks he was assigning because he had put a great deal of effort into developing the descriptors for the levels of the rubric. Dave also posed a question for the students’ journal entry that was related to this project. He suggested to the students that they should convince me that you understand how to use matrices to solve traffic flow problems. In Dave’s Assessment Log Book he wrote:

I asked them to “Convince me that you know about traffic problems.” in their journal entry. I found that they could have used more guidance on how to build an argument, not just give an example.” (Assessment Log Book, December, 1998)

When Dave and I met for our final interview, I asked him for further explanation of student responses to this “Convince Me” type of questioning.

A lot of them just used an example. They might have made up their own example but nonetheless, it was just an example. They wrote out a question and solved it. Now, they obviously felt that this should
convince me they understand it. But as I said to many of them, that
convinces me you can do it. It doesn’t yet convince me that you
understand it . . . So we talked after that about how to build an
argument. What do you offer as supporting proof? What kinds of
information do you put in, what do you leave out? Those kind of things.
I think it was a good exercise. I don’t care about the traffic flow
particularly. But the idea of about how to build an argument was
interesting.

Dave explained that he had put another “Convince Me” question on the final
examination and the responses were much better. I asked how he evaluated their
responses and he replied.

If I had time I would have built a rubric to evaluate this. I didn’t have
time so I essentially looked for content in a sense. The various
assumptions and the various pieces of the binomial distribution and I
looked subjectively at how convincing was the argument. As I say, I
would have preferred to do a rubric but there is only finite time and
that’s the way it goes. (Interview Transcript, February 2, 1999)

Dave’s reflections indicate his continuous professional growth in teaching and
assessment strategies.

4.3.4 Support for Authentic Assessment

Dave had several suggestions as to what helps him develop his expertise in
authentic assessment. They include attending presentations or workshops, refining
ideas that other teachers have suggested, working with other people in a group such
as our authentic assessment group, as well as creating his own ideas by recognizing
the mathematics inherent in a magazine cartoon or news article.

Dave frequently attends and presents at mathematics education conferences
and adapts the things that he learns to suit his own teaching style.

I would say going to conferences and hearing from other people who
have tried this stuff helps. . . But I think more than that from my point of
view I think what helps is seeing the kids be successful. I mean not everybody is successful. I don’t have classes where everybody passes but I think in general the kids are better served by what I am doing than by what I used to do. (Interview Transcript, October 1, 1998)

He also speaks of our initial board-wide assessment group that met on a fairly irregular basis.

That little bit of stuff that we did in getting together last year to talk about assessment. You know we get together and say “Oh yeah, here’s what I have tried.” and “I tried this and it really bombed but if I tried it again then I would do this differently.” It is nice to know that there are others out there even though they don’t impact on me directly. I can’t take the stuff that you do and lift it and put it in my classroom because I am not you. (Interview Transcript, October 1, 1998)

But again, he refers to gathering ideas “by accident”.

I would say that sometimes they happen by accident like the thing with the homework groups. Most of the time I get it by accident. I want to do something different with sequences and series so I kind of look around for sequence and series related stuff and . . . (Interview Transcript, October 1, 1998)

When I questioned Dave on the types of resources that he has found useful he responded:

I haven’t honestly seen a lot of ready made stuff in this area. Or if there is I don’t know about it. There’s the Harvard Project or one of those projects that apparently has a lot of stuff. In the school that I am in, none of that stuff would ever have been purchased so . . . So, I guess the short answer on resources is I expect that there is probably a bunch out there but I don’t know where they are. (Interview Transcript, October 1, 1998)
4.3.5 Problems/Stumbling Blocks

Dave perceives his major stumbling block to be time. He specifically focused on the time it takes him to build a rubric for an activity, and the time he spends responding to journals.

Time. The number 1 [stumbling block] is time. I am in a hurry to get the product in a workable form and although I have ideas there are lots of things I don’t start because I won’t have the time to do it efficiently now and so it doesn’t happen. That’s one big stumbling block. (Interview Transcript, October 1, 1998)

Dave mentioned several times that building a rubric takes a great deal of time. I questioned Dave on whether rubrics could be transferable. That is, could you use one rubric for several different activities?

Yes, every open-ended activity I see as needing a different rubric. Unfortunately. Because it would be nice if there was one template we could use. I mean you often are looking for similar concepts but they are specific to the activity. And it makes it easier to use if it is more specific. Which is really too bad. (Interview Transcript, February 2, 1999)

Dave responds to every students’ journal entry and although he thinks that there is great value in using journals he is honest about the amount of time it takes. He describes how he responds:

They write them on Friday. I give them some time in class to write. Every weekend I take them home and I give them a written response. To whatever they said, I write something back. Now, what I write back might not be a long story. I mean in some cases I write “Why don’t you come in for some extra help on this. I am available . . . ” Sometimes it’s a lot longer. Like the first few weeks it is when they did “My life in math”. My response there is anywhere from 1/2 a page to a page. When you do that for 2 classes worth of kids well, there goes my weekend. Now, I don’t assign a mark to it. I don’t restrict what they write other than I don’t want any obscenities. (Interview Transcript, October 1, 1999)
Dave uses these methods because he strongly believes that they are important but here he recognizes that there is only finite time to do things. "There is only so much time you can commit to new stuff" (Interview Transcript, October 1, 1998).

4.3.6 Summary

Dave believes that students should be learning more of the mathematics that is relevant to their lives and that they will find useful. He also views the mathematics classroom as taking on a more realistic atmosphere by encouraging collaboration and group work rather than students working in isolation. Dave's use of authentic assessment activities is evenly spread throughout all grade levels. He uses journals on a weekly basis and often chooses a group problem solving activity to introduce new concepts in context or to reinforce ideas the ideas that he may have taught through more traditional lessons. Dave has been working on his expertise in developing and using rubrics and feels that rubrics are an important assessment tool.

Dave expresses a great deal of frustration with colleagues who are unwilling to try new ideas and hence can often feel isolated or alienated. This isolation also creates a lack of meaningful assessment dialogue that could assist Dave through the sharing of ideas and resources.
4.4 The Case of Miriam

Miriam is an experienced teacher who is currently the Department Head of Mathematics at Woodrow Heights, a large suburban high school. Miriam has served on various committees in the school board that deal with assessment and specifically with developing assessment scales for numeracy skills. She also taught a summer institute course on using numeracy assessment scales to teachers within the board. Although Woodrow Heights is an established school, the staff are not reluctant to accept new ideas. The school has a unique timetable that allows one day a week for independent study for students and collaborative preparation or meeting time for the teachers. It has also experimented with establishing integrated studies during the implementation of a grade nine transition years program several years ago.

Miriam's secondary school and undergraduate education took place in Quebec where she obtained an undergraduate degree in mathematics with a minor in business. She started her teaching career in the 1970's in New Brunswick at a large secondary school. Her first teaching assignment included teaching electricity and her students were mainly male. After two years of teaching in New Brunswick she moved to Ontario. Miriam was hired as a half-time teacher at Woodrow Heights and later was taken on full-time. She has been there ever since. Some of her teaching experience in the early days included a few courses in typing. Otherwise, she was teaching mathematics.
Miriam has obtained a Masters Degree in Education, investigating teacher effectiveness in her Master's thesis. She specifically pursued a program that would include thesis writing because she wanted the thesis background in case she wants to enroll in a doctoral program.

4.4.1 Miriam's View of Mathematics and Assessment

Miriam values the problem solving aspect of mathematics and strongly believes that students should be encouraged to do mathematics in context so that they see the application of mathematics.

I view math as being more than anything problem solving. If you have the skills for problem solving, you can virtually teach yourself anything. And so that's the primary purpose in teaching math: problem solving. (Interview transcript, June 30, 1998)

Miriam suggests that she uses performance assessment because the types of activities included in this type of assessment are more realistic and broad-based:

The move to performance assessment is to me a really important move because I find that [otherwise] students compartmentalize the math. For them, it's fine to use your math in math class but they don't know how to apply it. (Interview transcript, June 30, 1998)

It is valuable to show the applications of mathematics because:

It is the math that people are going to use in their lives... And I think that is what bothers me is that there is so much of the math that we teach in class is in isolation. And that they [the students] don't make the connection in another context. (Focus Group Interview - November 4, 1998)

Miriam covers the traditional content in her classes and also introduces problem solving applications at every opportunity that she sees.

I would finish all the required curriculum and then just go do other things that were more interesting. You know I would just pose a
problem and they would work away at it. And you never knew where they would end up. To me, they were authentic problem solvers. (Focus Group Interview - November 4, 1998)

However, she acknowledges that authentic assessment is very time consuming and when I asked her why she does it since it is so time consuming she responded:

Because it is far more meaningful. It is far more transferable to real life. You said what do I value and what I really value is people doing math. And that was something that really stuck me while working on the vertical work team. We started talking about how we value things and how we set up the scales and so on. When it came right down to it, everything that you value is about doing math. I love going into a class that seems almost chaotic but as you are walking around you hear them talking math and that to me is fantastic. (Interview transcript, June 30, 1998)

Miriam also encourages the use of technology such as calculators and more specifically graphing calculators. She has attended summer sessions on using graphing calculators. Sometimes students become dependent on calculators and Miriam suggests that it is important that students learn skills of estimation:

It is much more important that we’re teaching estimation and reasonableness of answers. I mean sometimes you give them a simple question like it costs so much per mile or km and the distance to Montreal is such and such and they come up with a cost of $40,000 to drive to Montreal. Well, you know there are an awful lot of cars going to Montreal considering it costs $40,000 to get there. And their response is “Well, my calculator gave me that answer.” But that’s something that we need to be working on. (Interview transcript, June 30, 1998)

Miriam comments about the new mathematics curriculum that is being developed for the province and explains that the debate about what direction mathematics should take continues on a provincial level. Many mathematics educators are waiting to see if the new provincial curriculum will be a problems-based curriculum or one based on learning skills and algorithms.
I find it very interesting the direction that math is poised at taking right now. Because it is going to be very interesting to see what they do with secondary reform. Whether they jump to new ideas or whether they fall back to a very traditional content-driven curriculum: “You will learn this and this”. They just keep adding more and more stuff to what is already there. (Interview transcript, June 30, 1998)

Miriam tries to balance “covering the content” for the exam with activities that she believes have more value. She reveals her frustration with a content-driven curriculum.

4.4.2 Miriam’s Use of Authentic Assessment

Miriam uses authentic assessment whenever it is appropriate and when she has time to develop and test activities and their assessment. She has used journal writing and portfolios extensively in grade nine but has also used problem based activities and their assessment across all grades including grade twelve and OAC Finite. She also includes self and peer assessment in her class activities at all grade levels. For instance, Miriam uses self evaluation on all of her tests. Students evaluate themselves and the teacher.

The students at all grade levels always do a self and teacher evaluation on every single test. And I am very pleased with that because I worked very hard to get them to a point where they will be totally honest in their evaluation of me. And they won’t at first and then they finally do realize that if they say something negative they won’t get points against them or anything and that I will perhaps change what I am doing in the classroom as a result. But I also ask them to be very honest about themselves. That’s interesting. They are often harder on themselves than I would be. (Interview transcript, June 30, 1998)

Miriam responds in writing to each student on these self-evaluations on their tests.

She remarks that:
Quite often I am surprised that something I might find less than interesting, they really like. It gives me great feedback and information on individual and class learning styles. (Miriam’s Assessment Log Book, January, 1999)

Miriam attempts to incorporate student responses in daily activities and procedures. With most students, these self-evaluations and her responses create a running dialogue between students and teachers which she considers benefits both.

She also uses writing in other ways throughout her courses to encourage reflection and reaction:

I still will have them, occasionally, write a straight reaction to something that’s done in class or how they felt about something. I use a lot more “Explain how you would do this” rather than “Do this”. (Interview transcript, June 30, 1998)

Students in Miriam’s class keep a student log book and make entries once a week. She will often ask students to write something descriptive about a topic such as, describe the steps to factor a complex trinomial or it could be about their achievements or frustrations with a topic. Miriam reads the journals regularly, usually each time student write, and responds when appropriate. Miriam finds this very beneficial in discerning difficulties or misinterpretations. She also often writes on the topic herself and shares this with students. In particular, she will write a reflection if the class has not gone as smoothly as she had hoped. She finds that the students react very positively to the sharing of her own reflections.

Miriam uses performance assessment strategies with her classes and works on developing scoring rubrics with levels of achievement. One of her performance
activities with a grade nine class was based on measurement. She was surprised at how well the students handled the activity.

The first time I did a performance assessment I was stunned at how well it went. It was a grade 9 class and they weren’t very mature and yet they handled it beautifully. Their performance wasn’t so great but they handled the doing of it pretty well. I had interviews with the parents within a week and that was all the parents wanted to talk about. It was obvious that talk of this activity went home to the dinner table and met with a lot of discussion. It was so different from anything else they had done. (Focus Group Interview, November 4, 1998)

When Miriam had to assess the student’s performance on the measurement activity, she struggled with developing a scoring rubric using four levels of achievement. Here she describes how it evolved:

I have always marked for process rather than marking for the answer. But I must admit, the holistic scoring was a new idea. I like to have a definite idea in my mind as to what a level 4 is, a level 3 is and so on. But I would imagine that the more and more you do it, the clearer it becomes. I was nervous about sitting down to mark this grade 9 one. That was the first time I had used levels and it was interesting because I read them [the students’ solutions] all first and then went back and pulled out what I considered was very definitely, a sample of each of the levels. And then I went back and read them again and then read them again with the idea of putting them into levels. By the time I had gone through them 3 times, I found that I was much more comfortable with, “Yes, this very definitely is a level 1 or this is a level 2.” So, as I said, I used that simply to get more comfortable with it. (Focus group, November 4, 1998)

With the introduction of graphing calculators and a board policy that allows the use of calculators, including graphing calculators, on tests and exams; traditional assessment strategies need to be reworked.

It was very interesting because this is only the second year that we have had graphing calculators in all of our exams. It has been an argument constantly in Finite because there are so many things you can do so much more easily on the calculator. It was hard to set the exam this time so that that would not be an advantage. But I was really pleased the
There was a lot more interpretation and clarification questions. If this is what ends up on your graphing calculator well, what does it mean? Or how do you do this instead of just doing it. You know, someone has been called away in the middle of this and this is what is on the calculator. What do you do from here? And then they will interpret it. I think in some ways we are asking a lot more difficult questions because they are not spending all of their time doing manipulation and how do they take all this massive information and make some sense out of it. (Interview transcript, June 30, 1998)

Miriam also uses alternative assessment ideas in her more traditional tests and quizzes. She often has the students make up a question on a particular topic and then answer it. She usually asks them to “disguise” the question so that it is not just a recall of class examples. Miriam gains much insight from the level of difficulty of the student’s own question into the student’s comfort level with the difficulty of the topic. Miriam notices that the students become much more willing to take risks and become creative with their questions as the year progresses.

Miriam’s use of authentic assessment includes journals, logs, performance assessment, rubrics, and more open-ended problem solving. Several specific examples will be illustrated in the subsequent section.

4.4.3 Examples of Assessment/Problem-Solving Activities

This section will detail several instances of Miriam’s open-ended problem solving tasks and their subsequent assessment. These include: an assessment of a problem called “Mama Mia” that was used in her OAC Finite class, a grade nine and ten bouncing ball activity to explore the concept of slope, and a performance activity in grade 11 that used graphing calculators to find lines of best fit and correlations.

Miriam encourages students to explore mathematics through problem solving.
One of her examples is the "Mama Mia" problem [Appendix E - 1] that is best solved through a linear programming approach. She started her class on this problem as an independent project with very little preliminary teaching of linear programming.

They were going to do linear programming in Finite and I started off by giving them this Mama Mia problem which comes right off the Internet. And with no information at all, they had a day to turn it around and give it back to me with their solution. Then we put them through a little independent unit on linear programming and we gave them back the same problem again but with a couple more questions in it. Again it was fascinating to see how they approached it. (Interview transcript, June 30, 1998)

I asked Miriam how she assessed this particular problem solving activity and she responded:

I think the first one I literally marked out of 10 and it was basically had they attempted anything or not. And then sort of "How logical is their argument?" It was a very loose scale, which I am not all that comfortable with. I tend to be very objective. I like having so many marks for this and so many marks for that. . . . But the actual linear programming units were marked very traditionally and then the final one [the second attempt at a Mama Mia problem] was basically marked fairly traditionally too. However, I also marked their approach. Some of them came up with ways of doing it that I never would have thought of. I assessed how logical they were in dealing with the situation. So it was whether they picked that up or not. And as a matter of fact they took much longer to mark because they [the solutions] were all over the place and I had to look at each one individually. I suppose that's one of my concerns with authentic assessment is the amount of time that's involved. (Interview transcript, June 30, 1998)

Miriam organizes an investigation for grade nine and ten students that allows them to explore the concept of slope. This is a group activity in which each group is given a different type of ball and they drop it from various heights and record how far it bounces. She gives them very few instructions other than to record the data and try to make some sense of it, to put it in some sort of order.
Their question is, they have to decide how high the ball will bounce from the CN Tower and so on. They are basically just given the ball and they go off and try to solve it. You know the first thing they say is what do we measure from, the bottom or the top of the ball. And I won’t answer. They have to make that decision on their own. And they would come back and eventually work themselves from the physical model to having a chart model and then having a graph model and eventually trying to fit an equation to it so that they have an equation model. The whole idea is modeling which I think is tremendous and powerful. We don’t use it enough. (Interview transcript, June 30, 1998)

She includes some other requirements in the experiment. The students must critique their own way of running the experiment and draw graphs on chart paper which they later share with the entire class.

It is fascinating to watch them. When they get it finished, they have their graphs done and they have to put their graphs up to share. I tell them that the graphs have to be put up in some type of order and that is all I tell them, nothing else. And they have to decide what that order is. So, they will invariably take the graphs and put them in order of steepness. (Interview transcript, June 30, 1998)

Miriam did not share how or whether she assesses this activity. However, it is significant to mention that every activity does not need to be formally assessed.

I observed Miriam’s grade eleven class on the second day of a performance assessment task [Appendix E-2(a-g)] that was an investigation of footprints left at a crime scene. The students used graphing calculators, the clues of stride-length and other evidence in the footprints, and their knowledge of linear regressions and correlation factors to determine the suspect in a crime. Students would be given four days to complete this activity and I was arriving on the second day. On the previous day the students had received a copy of the three page performance assessment task [Appendix E-2 (b-d)] and had been placed in their groups. At the beginning of the
that I was observing there was a brief whole class discussion which was basically a reminder of what they were doing that day. Students have class every other day and this often necessitates a quick recalling of the last class at the beginning of the period. After this quick summary, the students moved into their groups, signed out graphing calculators that Miriam had brought with her, and picked up metre sticks or measuring tapes. The groups began very quietly and took a few minutes to build momentum. Miriam had explained that this was a very subdued class and she was concerned about whether they would be fully engaged in this activity. After a few moments, students in the groups started moving. Some were out of their seats walking and measuring, others measuring heights, others were trying to teach one another how to use the graphing calculator. Miriam quickly began circulating the room and had a clipboard with a checklist for Group Evaluation [Appendix E - 2e] to record her observations. She gave very few prompts but did mention “If you need space, you can use the hall as long as you’re not too noisy.” One group actually moved outdoors to the courtyard because there was a small garden plot in the middle of the courtyard and they could investigate how footprints are formed in the mud since the diagram of footprints that they were given showed different levels of indentation for the heel and toe marks. Other groups moved to the hall. By this point, most groups were up and moving about, either running or walking and measuring one another’s stride length and height to use this data with their graphing calculator to see if there was a correlation.
About mid-way through the period, the class had become quite lively and there was plenty of purposeful chatter. The students seemed comfortable enough to be asking me questions and asking for suggestions. One group asked if I could help with their experiment and before I knew it, I was taking strides down the hall in my stocking feet and they were measuring my stride-length and then my height. They had me walk, walk quickly and then jog down the hall. Most of the period was spent collecting data that they would analyze at a later date.

Although I was not present on the following days when they completed the activity, Miriam reported that they really “got into it.” Through the students’ journal entries, Miriam noticed that the students thought it was “a lot of fun.” She also disclosed that one boy who was usually extremely withdrawn in a whole class setting was very engaged in this small group activity, and after the activity was completed he continued to be very engaged in class, including whole class discussions. In fact she mentioned that the whole class had “lightened up” after the activity.

The culminating activity was each group’s presentation to the class of their argument for who on the suspect list was most likely. I spoke to Miriam shortly after the presentations. Miriam discussed that one thing the students learned is that there is not always one right answer in a realistic context. The data did not lead to a clear suspect but only narrowed it down. Students needed to interpret the data and they recognized that real life math is “messy.” The correlation coefficient was .61 therefore couldn’t make a clear correlation between height and stride-length. They
recognized that perhaps there was other data that should have been gathered at the crime scene.

Miriam made several comments about the students' performance on the activity and what she would do differently next time. The students were not as adept at gathering material evidence as she had expected. The next time she uses this activity, she might do some preliminary work on statistics concepts such as choosing an appropriate sample size. She might also discuss how data is collected and subsequently used, tying it in with their experiences with science experiments. She also expects that on subsequent similar activities, the class will be more familiar with the procedures of a performance assessment. However, overall, she was very pleased with the assignment and with the process that the students pursued. Miriam used a combination of assessment tools for this performance task. These included teacher assessment of group work, teacher and student evaluation of the oral presentations [Appendix E- 2g], and a student self-evaluation [Appendix E-2f]. (Post-observation interview, November 26, 1998)

4.4.4 Support for Authentic Assessment

Many of Miriam's authentic assessment activities began with a small idea and grew. Her "Mama Mia" assignment started with an item she obtained from the Internet and then she expanded it. She has done other experiments that started with a simple idea such as wind-chill and the bouncing ball. Miriam finds that her best
resource is communicating or working with other teachers. Many of her ideas were
stimulated by ideas from other teachers or workshops that she has attended.

You know what helps the most is talking with other math teachers. I
finally got around a couple of years ago to completing my Honours
Specialist in math and we had a fabulous time. . . It was probably one
of the most rewarding professional things that I have done. We just had
this fantastic group of 40 and it was just probably one of the best
professional challenges that I have been through. But one of the things I
found absolutely wonderful about it was the amount of talking that we
did. Nearly everyone had been teaching for at least 10 years and a lot of
people at that point were concerned with the new destreamed grade 9
program. There was a tremendous amount of sharing about math and
they designed the course in such a way that we were often doing little
demonstrations and presentations. . . . I came away with probably a
couple of binders of activities ready to be used in the classroom. It was a
tremendous renewing feeling. . . . I found that by the end of the time I
was just roaring to get back into the classroom to try some of the new
ideas. Just great professionalism. So I think a lot of times that’s what I
find useful - being able to collaborate which we don’t seem to get
enough time to do. . . . It’s wonderful to work together, but it is just that
time commitment. (Interview Transcript, June 30, 1998)

I asked her if there is anyone at her school that she can collaborate with and she
responded that there is one person but that often they are not teaching the same
courses or have the same time free for collaboration. She is in a department of ten to
twelve mathematics teachers. However, when the school began the transition years
project several years ago the principal at the time made a point of freeing up grade
nine teachers so that they could work collaboratively.

We used to (have time to get together) when B. was the principal. She
was wonderful at freeing up the grade nine teachers to give us some
time to plan. Just getting together helps. There isn’t that type of leeway
now. Before there was money to pay for supply teachers to free us up
for a couple of days to work on curriculum. She was very supportive of
that. I don’t find that’s true now, unfortunately. (Interview transcript,
June 30, 1998)
As Miriam states administrative and board support is necessary both for teachers to have time to work together and so that teachers recognize that spending time working collaboratively is valued.

4.4.5 Problems/ Stumbling Blocks

Miriam would suggest that there are two major stumbling blocks to doing all that she would like to do in both problem solving and authentic assessment. One of those is time and the other is the push to "cover the content".

With respect to time, Miriam is speaking both of time to prepare materials and time in class to do all the prescribed curriculum plus other things that she things are important. Miriam is in a non-semestered school, and the large number of students that she has to teach strongly affects the sorts of experiences that she can pursue.

Miriam acknowledges that often her time in class is filled with just delivering content to students and she would love to find a way to incorporate the content and do more meaningful problem solving activities and assessments.

I feel very constrained a lot of times by the curriculum because we have so much to cover . . . and it's hard trying to get it all done. (Focus group interview, February 11, 1999)

She has often tried to find ways of incorporating the content in more authentic activities but that is a very time consuming job to be done by just one teacher.

I wish I could have more time outside of class to figure out how to incorporate more, to get away from that traditional following exactly what the Ministry has laid down to teach. . . .

But you need a great deal of time to write the curriculum that way. It amazes me sometimes that I will spend ten hours or more developing something that takes two classes and then it is done and gone. And then
you know part of it is putting it together and part of it is running it through to see if it works. (Interview transcript, June 30, 1998)

Miriam also refers to a current situation where teachers are losing some of their preparation time due to cutbacks. In semestered schools, teachers may have no preparation period in one out of the two semesters.

There are so many time constraints. I don't know how it would be in a semestered school. I can't imagine going through a whole semester without a prep period. It is going to be harder to do as good a job because certainly I don't teach the way I was taught math. When I was taught math it was open your book to page such and such and you read and then you did. If you had some questions you might get them answered, you might not. I would hope that my students are having a far more positive experience with math. (Interview transcript, June 30, 1998)

As well as time constraints in delivering a creative curriculum, Miriam encounters opposition from several of her colleagues. This creates an issue of isolation and as being seen as "odd person out." Miriam sometimes feels that she is working in isolation and this can be a major stumbling block. Teachers need the support of their colleagues.

4.4.6 Summary

Miriam is an experienced teacher who believes that mathematics should be relevant to students by being set in a realistic context. She suggests that students should see the mathematics that they are going to use and that problem solving should be embedded in realistic contexts. Miriam is also a risk-taker and creatively adapts ideas that she seeks and discovers outside of the classroom. She develops innovative activities and is likely to test these activities with her students leaning on
her knowledge of mathematics and pedagogy to adapt or extend the activity to suit students' needs, interests, and abilities.

Miriam uses authentic assessment activities at all grade levels and scatters these activities within a traditional teaching situation. However, she is constantly striving to increase her use of authentic assessment activities and to develop curriculum ideas within these activities. Miriam views a lack of time as a major stumbling block. This includes time to develop activities as well as time within the course to include the activities. She also expresses a strong desire to dialogue with other colleagues who are using authentic assessment.
4.5 The Case of Luke

Luke has been teaching for eleven years at both elementary and secondary levels. Luke started his career teaching mathematics and working with students with specific learning needs in an elementary school for two years. He then moved into secondary school mathematics teaching and at the time of my initial work with Luke, in the Spring of 1998, he was teaching mathematics at a large secondary school and was the Assistant Department Head of Mathematics. He had been at the school for about six years and at the time was teaching grade nine, grade twelve, and Calculus. In June of 1998, after teaching secondary school mathematics for eight years, Luke decided to make another change to move from the secondary school to a senior elementary school to teach grade eight mathematics. Thus, during the second half of this study, Luke was teaching grade eight mathematics.

The fact that Luke was technically an elementary teacher during the second half of the study posed a problem. This study is specifically about secondary school mathematics teachers' experiences with authentic assessment. The dilemma of whether Luke's case should be included thus arose. I decided to continue with Luke's case study because I recognized that Luke's juxtaposition of his elementary teaching experience with his secondary teaching experience added a new dimension to the data. Luke has the experience of implementing authentic assessment in two different settings and is able to take the perspective of both senior elementary and
secondary school teacher. As well, Luke's elementary experience during the study was in a grade eight class which may not be that far removed from a grade nine class.

Luke's background includes an undergraduate degree in Music with sufficient mathematics courses to allow him to be qualified to teach mathematics as his second teaching subject. He is currently taking mathematics courses in order to have sufficient mathematics credits to take the Math Honour Specialist course. Luke displays a keen interest and love of mathematics. He has a Masters Degree in mathematics education and is thinking of pursuing further studies at the doctoral level in mathematics education. Luke has been involved in the initiative of a board-wide Mathematics Education group which encourages mathematics teachers to get together to discuss readings such as articles or research papers about mathematics education. He is currently on his school board's Numeracy Vertical Work Team and towards the end of this study he was chosen as a writer on the team of authors preparing the provincial course profiles for a new grade nine mathematics curriculum. Luke is very involved in mathematics education at several levels.

Luke's schools during this study were Jordan Fields Secondary School and Hillview Senior Public School. Jordan Fields School is ten years old and was opened a few years before the implementation of Transition Years, a Ministry of Education initiative for grades 7 to 9, and the staff was piloting the implementation of many of the policies of this initiative. Like Glenview, Jordan Fields School had a grade 9 report card that was not oriented towards marks but towards the achievement of outcomes. In September of 1998, Luke moved to Hillview Senior Public School and
taught a grade eight combined science and mathematics course as well as a class of Special Education. Hillview Senior Public School was implementing a fairly new provincial grade one through eight curriculum as well as a new provincial report card.

Luke attributes part of his decision to move from the secondary level to the elementary level on the frustration that he has felt with the emphasis on "covering the content" in secondary school mathematics. The dichotomy of elementary versus secondary teaching was brought forth during much of the interview. Here Luke speaks of his previous experiences in the elementary school before moving back to the elementary level in June:

I think there was a greater sense of what we were doing as a school [in the elementary level]. In a high school setting, things are so fragmented that you don’t get a sense of what we’re about and how to help kids. There was a sense of purpose [at the elementary level]. And a big part of this was that at the school I was at, the student was important there. As well, it was set up as “student as inquirer”. Which fits well with my view of how I like to teach math which is making sense of math rather than covering topics. (Interview Transcript, May 19, 1998)

In his new situation at the grade eight level, Luke is discovering that he has more flexibility to teach a project-based curriculum, and the combination of mathematics and science curriculum that he is delivering allows him to more easily make connections.

Every day in science we have a hands-on activity. This highlighted for me how powerful this is for kids. . . . We ask kids to do tasks and we mark them which is very tiring but when you create something it is enlivening, then it is worth it. (Interview transcript, November 13, 1998)
4.5.1 Luke’s View of Mathematics and Assessment

Luke feels that mathematics should be understood rather than memorized. He believes that students should be making sense of mathematics and sees his role as much more than the transmitter of knowledge. He thinks that many of his ideas about teaching mathematics came from being trained to teach music.

It was a great coincidence that I studied composition the same year that I studied mathematics. When composing, I learned about music on a much deeper level than I had ever known music. ... Music education has to justify itself so you think about it and we did talk about it, we did small research projects and we looked at different views of why music education is important. That is what I brought to math education. (Interview Transcript, November 13, 1998).

He attempts to focus on learning activities that are authentic, that have context, that relate to something outside of the mathematics classroom.

For me the notion of authenticity is "Is the mathematics you’re doing actually authentic mathematics?" Or is it just an isolated topic. And is the teacher as leader telling kids what to do? Or is it a chance to explore? Are they behaving like true problem solvers? Is the stuff that we are assessing even authentic, never mind the techniques that we are using. So can you have authentic assessment with a traditional type of curriculum? (Focus Group Interview, November 4, 1998)

This type of curriculum requires delivery in a less teacher-directed approach so that students make sense and understand the mathematics. Luke describes his expectations at both the secondary and grade eight level:

I wanted to think of learning activities and so I’ve been focusing on activities that I guess encourage or have the kids making sense of things more on their own than on the transmission approach. Now, that’s not to say that I always use it. I do talk and teach at the overhead a lot but even there I’ve tried not to be terribly explicit and leave room for the kids to make sense of things. For instance in solving linear equations. My instructions are very vague in that I don’t say “Do this, do this”. It’s “Here are the goals of the process” and I do expect the kids to make some connections themselves. (Interview Transcript, May 19, 1998)
Luke has several goals as a mathematics teacher that include goals in mathematics as well as metacognitive and problem solving skills. In responding to my questions about his goals as a mathematics teacher he acknowledged:

I am stealing from Piaget when I say “Intellectual and moral autonomy”. That’s the goal of school. Math means learning concepts to use elsewhere. Learning to learn. Growing as a person. That is a part of it but yes, you have to know your math. I guess it is part of the teaching process that we need to get a sense of where kids are at in terms of their prior understanding and get them to the next step. So that is a way to get the big goals together. Find out where they are at, design some intervention. I mean intervention as being a new experience where kids can engage and identify what they use and get further along. And then take responsibility for making sure they are on track and figuring out the process, in terms of participating in the learning process. We need to get kids involved in that process. (Interview Transcript, May 19, 1998)

Whether at the secondary school or elementary school level, Luke displays an awareness that he is teaching the whole student rather than simply delivering mathematics content. Luke sees mathematics as a process and learning and teaching as growth in the process of mathematics.

He also views mathematics as an integral component to problem solving. He considers mathematics teaching as teaching concepts which students then apply to problems.

I see the role of math to apply one’s conceptual understanding in a wide variety of situations and to be able to extend beyond the traditional kinds of classroom problems that we do assign. So, I guess I start by seeing teaching math as teaching concepts and we get at those through the various kinds of task that we ask kids to perform. (Interview Transcript, May 19, 1998)

Luke sees problem solving as a key component, allowing students the opportunity to apply their conceptual understanding to a wide variety of situations.
I think kids need to learn that they can apply what they know in other situations and they should be accustomed to making sense in new situations in terms of what they already know as opposed to waiting to be told. So there is an autonomy, an intellectual autonomy issue there. There is “looking at math as concepts” not skills. Problem solving for me is just part of the continuum of understanding. At one end you can follow the teacher and then at the other end you can do the familiar types of problems but being able to apply the conceptual knowledge in contexts where you can make sense of the parts but also have to make sense of the whole. For me that is the goal. (Interview Transcript, May 19, 1998)

Luke discusses the notion that there are many different types of problem solving and questions whether teachers are truly giving students problem solving opportunities in their class.

I contrast problem solving with puzzles that some teachers give when they think they’re problem solving but that are really puzzles that don’t, well, they aren’t really significant in developing one’s conceptual understanding nor are they relevant in any real world application. So, I think that there has to be some sort of real world that they can import from them. (Interview Transcript, May 19, 1998)

Luke views this problem solving approach as developing conceptual understanding because it is taking a mathematics concept and using it in context in a problem solving setting. Luke recognizes that this takes a great deal of time and flexibility.

I think we need to address conceptual understanding and problem solving. Problem solving takes time. The grade nine EQAO testing [provincial testing that uses performance assessment] takes time. . . . If you try to give too much flexibility then you lose sight of the concepts and can’t relate one thing to the other. (Interview transcript, November 13, 1998)

Luke refers to a problem solving component in the grade nine mathematics program at Jordan Fields Secondary School and explains how it operates.

So in our grade 9 program, which I am leading, we have a problem solving component with every test and it reflects the concepts that we have covered in that unit. So, for example, on the test on the unit on
whole numbers, in which we included scientific notation, the kids had to add numbers in scientific notation which was an extension of what they had been taught. We gave them the hint: think like terms. So, we were hoping with varying degrees of success, that the only way you can add these is to make the exponent on the power all the same. They [the problem solving components] are just getting off the ground this year. I went over the course last year and wrote the curriculum, the course of study and we're developing a problem solving component in it. (Interview Transcript, May 19, 1998)

His focus is on problem solving in an authentic context and the focus of his teaching is to prepare the students with the skills they need to solve problems. He also wants students to understand mathematics rather than memorize it. He describes his introduction of trigonometric concepts in his grade twelve class:

I typically don't actively go out and say “I want to solve this problem.” But I do reflect on them. One classic example is how I introduce [the concepts of] sine and cosine. I deal with the circle. Now, that is just a logical extension in my mind from projecting vectors into their horizontal and vertical components from physics. And it turns out that there is a lot less to learn. It's a more complex metaphor or idea for sin and cos but then there is a lot less to memorize. Again I don't want kids to memorize, I don't want them to memorize bits. If I can give them concepts, then it is much better. Sure - they could memorize SOHCAHTOA, the CAST rule and the alternating angles. The nice thing about the “wonderful circle” is that I can say to kids “Okay, what's the sine of 80, approximate it and they can come pretty close. They can visualize it. They can problem solve. I give them a scaffold, a situation, so that they can problem solve within this context that I've created for them, right away. (Interview Transcript, May 19, 1998)

Luke believes that authentic assessment activities should first be built on authentic mathematics.
4.5.2 Luke's Use of Authentic Assessment

Luke explained that it is often difficult to separate the learning activities that he does with his class from assessment. At both the secondary and grade eight level, it is all part of his classroom routine.

The lessons I give are often preparations for activities. Here do this because it is a skill you will need and then the problem solving that follows. (Interview transcript, November 13, 1998)

His assessment includes traditional tests as well as rubrics, letters, strategic planning, conferencing, and feedback to students through written comments. Luke discusses his use of rubrics in secondary school mathematics:

Well, I think that what I do is driven by what I want to accomplish in a classroom. So I have used rubrics, particularly for assignments where there are a number of different aspects of the project that I am looking at. . . . Part of that is efficiency too. They are really efficient to use once they have been used in kind. (Interview Transcript, May 19, 1998)

Luke considers rubrics as giving a clear understanding to both students and teacher about what criteria will be used in judging achievement. Rubrics make it easier to feel confident about assessment.

Rubrics were useful because I wanted to convey information to kids. I just didn't want to give a mark. I really feel badly about giving anyone a mark and then not being able to learn from that experience. So, whenever I give something back, I want to convey as much information as is possible so that kids have a very clear understanding as to how I arrived at the mark so that they will know for next time. And so the rubrics allowed me to do that. My wife has used them at the elementary level and said perhaps complementary things about them. "Now I know why it is a 3 out of 5 and not a 4 out of 5." (Interview Transcript, May 19, 1998)
Luke gives us some insight into the type of learning activities that he has used with his grade seven and eight students and how he uses the information from the activity for an informal assessment.

I gave the grade 7 kids the problem of how fast can you walk? And I gave them a week to do it. Day one they had to tell me what equipment they would use, day 2 was to collect data, and day 3,4, 5 were to determine as a group, to determine km/hour and then they had to do a formal write-up to explain what they did. . . . Well, we didn’t have marks back then so one could talk about how one participated in the learning process, because that was part of the report card, and even the outcomes, there was a lot of sharing of what was learned from one another. I guess in some respects, I was more focused on milking it for the kids to reflect and get as much out of it and not focused on attaching a number to it. At report card time, I would reflect back. I was recording data on process but I did do things like have them hand in drafts and I would comment. And then hand in a final draft and I’ve done that. (Interview Transcript, May 19, 1998)

Luke also discusses the difficulty of assessing such learning activities. He also focuses on the importance that he places on the learning process and on students reflecting on their work.

Luke frequently has students write letters to give them the opportunity to reflect on their learning and to assume responsibility by developing their own plan of action. He prefers this over journal writing which he feels is often artificial.

Letters. I have used a journal but it strikes me as being kind of artificial. I do ask them to write letters with a specific goal in mind and I think that gives it some relevance and some meaning to the kids as opposed to just “write”. A lot of journal writing has struck me as being like “now write” without a purpose so I think kids have a bad feeling about journals. But I have them write a letter or an explanation to me. It accomplishes the reflection, getting kids to reflect about what they have been doing but it seems more purposeful. (Interview Transcript, May 19, 1998)
In secondary school mathematics classes, Luke uses this letter-writing approach at the beginning of the year and in tests as well.

So I include letters in my Chapter Tests. For example, this semester I have had kids at the beginning of the year write me a letter to explain to me what I need to know about you to help you. What are your thoughts and feelings about math with the focus being “What can I do to help you.” And then I typically would either jot down a few things and give it back to them or I may speak to a student individually to address that. (Interview Transcript, May 19, 1998)

Luke’s use of open-ended problems is similar to asking students to write about what they know. During our focus group discussion he informed the group that once he gave a test in Calculus where he merely asked students to convince him that they know the questioned unit of work. This created a lively discussion between participants and many of the participants have used this “Convince Me” notion in both formal and informal assessment with their classes.

Luke tries to help students develop responsibility for their own learning and incorporates this in his assessment strategies. In senior grades, Luke employs a device he calls strategic planning [Appendix F - 3].

In OAC Calculus we are doing what I call Strategic Planning for a participation mark. The focus is to do something that they haven’t done in their learning to see if it helps. Every student is obliged to make study notes and then the students have a list of things they can choose from to do on a regular basis to try to improve themselves. They can have a log, a question log, or work together in a study group. There is a list of things, also including reading ahead and making notes. And then the kids respond to me, I may make refinements and they will share as a group in class discussions to see what kinds of things they might try and how they might improve upon personal strategic planning. (Interview Transcript, May 19, 1998)

Luke has also used the strategic planning with his grade twelve students.
Now that Luke has returned to teaching grade eight classes he has found the opportunity to do more open-ended problems with his students and to incorporate project-based learning in his cross-curricular program. He evaluates problem solving using four levels that correspond to the Mathematics Achievement Chart that is used for assessment and reporting. He also uses anecdotal comments on his Problem Solving Evaluation [Appendix F - 4]. The focus on project-based learning and on cross-curricular studies, coupled with a grade eight report card based on levels of achievement, justifies further use of alternative assessment techniques. Here Luke talks of one of his experiences:

I did a performance assessment with a . . . It's really the first one I had ever done, about 3 weeks ago and I was shocked at how well it went. It was open-book and they could ask me for help. I documented the help I gave and I used those notes as well as the kids solutions as a basis for evaluation. I was able to get to every kid in the class at least twice to answer questions. What was interesting was that some of the kids needed coaxing to get going but once they got going they just took off. So often the kids don’t get there because they are not allowed to look things up or to ask for help. It was so powerful and I was really pleased with how well the kids did. I wanted to share that as an encouragement. (Focus group interview, November 4, 1998)

Luke’s experiences with the grade eight report card based on levels of achievement were of interest to the other participants during our focus group discussions. The secondary school teachers were anticipating the arrival of a new grade nine report card the following school year (1999/2000). This new grade nine report card would be very similar to the new grade eight report card that Luke was using.
4.5.3 Examples of Assessment/Problem-Solving Activities

My observation of Luke’s grade eight classes consisted of two sessions, one was at the initial stages of a project and the other was during the final student presentations of the project. The project was the “Shampoo Investigation” [Appendix F - 1]. This investigation was to examine shampoos for their popularity, physical and chemical properties, marketing and manufacturing strategies and the relationship between why people say they like their shampoo and the shampoo’s actual physical properties. On my first day of observation, Luke began the class with a short whole class discussion of what they would be working on during that period. Luke explained the assessment of the project and mentioned that during the period he would be conferencing with some groups while others would be working on testing the shampoos. There were tables at the back of the room, one of which had a set of microscopes, another a collection of beakers, and another a set of scales and rulers. There was a computer in the room for the students to conduct research through the Internet. There were also schedules posted on the wall that included a conferencing schedule (Field notes, November 9, 1998).

Students appeared to be very task-oriented and each group seemed to be occupied with a different task. One group was working on making their graphs and arguing about choices of scale. Another group of students was testing the viscosity of the shampoo by dropping a marble into the shampoo and timing how long it takes the marble to drop to the bottom. Another group was looking at the shampoo through the microscope and describing what they saw. I also spoke with one group who were
preparing graphs that showed the results of their survey. They had graphs that showed the variety of hair colours and types of shampoo used. They were also displaying which shampoos' scents were preferred. I noticed that each group had made up their own work schedule on chart paper and these were posted on the side walls.

As students were working, Luke conferenced with one group at a time. I sat in on his conference with a group of three girls. Initially, Luke explained that the purpose of the conference was to make sure that they knew how to do a survey. They would receive a mark out of 10 for what they did and a mark out of 5 for how well they functioned as a team. Luke asked questions of the girls individually rather than asking the group and letting any of them answer. The questions included: Were there any questions for which you got unclear results? How did you organize your data? What question would you ask next time? What would you do differently?” Students then asked questions about their presentations: “What should it be like? What should they say?” One student said that they had wanted a list of ingredients for the shampoo and called the 1-800 number that was on the shampoo bottle. At the conclusion of the conference, Luke told the students their marks. He told them that their responses rated a Level 3 and that for a Level 4 they should have clearly thought about these questions ahead of time. Thus all students in the group received a mark of 7.3/10. The mark on how the group worked together was 3.5/5. Luke apologized to me for not having a rubric. The girls left the table but then came back to question why they all got the same mark. Luke explained that he really did not have enough
evidence to distinguish why one would get a higher or lower mark than the other. During the post-observation interview, I questioned Luke on “Why a mark of 7.3/10? Where did he get that number?” He explained that the four level scale is actually viewed as having levels such as 3+ or 2- and that a 7.5/10 is considered a Level 3 performance and 7.3/10 is considered a Level 3- performance.

Luke then conferenced with a group of three boys and did not have time to finish before the period ended and the class had to clean up. At the conclusion of the class I asked Luke whether students were familiar with conferencing and he said that they were. I also asked about the notion of levels. There are four achievement levels in both mathematics and science. He felt as though the students were very aware of what constitutes a level 3 performance because they had been assessed using rubrics and levels of achievement throughout elementary school.

I returned to the school at the end of the week to see the shampoo presentations. Students were given an assessment sheet to assess their peers [Appendix F - 2]. The class was very quiet and attentive during the presentations. It appeared that they took the presentations seriously. Each group took their turn standing at the front of the class, fastening their large pieces of paper with charts and graphs to the chalkboard and presenting their work. Each group had nine minutes to present. The groups appeared confident and proud of their accomplishment. In most of them, all students took turns presenting, however, in one group, one boy said everything. Another group had tried some extra tests on the shampoo, as well as those that were required. Luke would remind the groups of their timing and the
necessity to allow enough time for everyone to present. Towards the end of the period, the audience became a bit restless and the presentations had to continue a few minutes past the "bell". The students were polite in waiting until all of the presentations were finished.

Since it was the last period of the day, Luke and I were able to dialogue immediately after the observation. Luke was very pleased with the development of the shampoo project. He saw the project as an excellent problem solving experience that included deadlines, planning, decision-making and organization of information.

The most important thing for me is that the students were working by themselves in groups and solving problems. I guess there are many dimensions to that. There's learning that I don't know how to do this and Johnny does. There are deadlines and they have to plan ahead. There's being responsible for everything that the group needs to be responsible for and there's staying on task. (Post-observation interview transcript, November 13, 1998)

Although Luke was pleased with the problem solving aspect of the project, he recognized that the students' ability to synthesize and then to present their findings needed further development.

Now what did happen was very little synthesis and maybe they aren't supposed to be responsible for that. Maybe they need to start thinking beyond their answers. You know some of them did embark on evaluation of the lab experiments and so on. They came up with their own reliability. So the follow-up for this activity will be that we'll talk about the need to do a presentation of that and not talk about just reading the numbers out which for the most part is what they did. The next step is to go that extra step and to say the numbers here said this and that and there is a relationship in viscosity. These are the popular shampoos and these are their features and therefore that is the factor. (Post-observation interview transcript, November 13, 1998)
Luke recognized that often it is difficult to foresee just how far students will carry a project. A teacher can expect too little or too much. He also sees that the evaluation of this project, while originally thought to be a summative evaluation is actually also formative because it is giving him information about where students are at and what needs further development.

This is very much formative now. I never had to do that before. What is reasonable to expect at this level? This is a particular stage of development. But the ultimate goal would be to use this to learn even more about what is happening. That's pretty authentic. (Post-observation interview transcript, November 13, 1998)

4.5.4 Support for Authentic Assessment

Luke appears to work on his own a great deal. When he was at Jordan Fields, he would have preferred that the department take a more collaborative approach but when that was not happening, he proceeded on his own. Luke seems to have a distinct vision as to what his mathematics class should be like. He feels that he can create a mathematics class that is closer to this vision when he is working at the grade seven and eight level. He has found that the integration of science with mathematics has given greater authenticity to the mathematics that he presents.

The integration of curriculum helps a lot. To be able to do things that tie together and it might be . . . Looking at high school . . . we have textbooks but here there are lots of materials to support the program. (Interview transcript, November 13, 1998)

He has found that using levels in reporting at the elementary school level has made it easier to align the authentic assessments with summative evaluations and thus reporting. When Luke was at Jordan Fields, he used a grade nine report card
that was not a traditional high school report card and this also helped with the translation of authentic scoring into reporting information.

At the elementary school that I was in [previous to being at Jordan Fields], I was developing a report card to reflect the transition years and it got at some important things about teaching such as taking responsibility for your own learning which is very important. Now, we [at the secondary school] have moved in that direction here and we made some changes to the report card. So, now our grade 9 report card reflects problem solving, communication, participation, and other such things. So that shapes what we do. I have a say in how that's come about so I think that's a fair compromise in terms of what I thought we should be doing and what direction the school was taking. (Interview Transcript, May 19, 1998)

Luke has found that meeting with other teachers with like minds is encouraging and helps to remind him what he thinks is important and thus pushes him to continue to practice what he believes in. Hence, Luke becomes involved in many board-wide initiatives such as the Math Education Group, the Numeracy Vertical Workteam, and Course Profile writing.

4.5.5 Problems/ Stumbling Blocks

One of Luke’s most prominent stumbling blocks was at the secondary level, the pressure to cover large amounts of content. At the secondary school level, Luke was frustrated at the pressure to cover content at the expense of having sufficient time to pursue more open-ended problem solving activities.

The biggest hindrance is that we have this much to get done by this date and in some courses we’re afraid to let go. We are afraid to say you really don’t need to know every mix of problem in calculus. You really don’t need to know rational expressions. When in the real world do you ever use an exponent bigger than three? So, why do we have $x$ to the 11th and $y$ to the 47th? (Interview Transcript, May 19, 1998)
He also sensed a resistance or reluctance on the part of many of his colleagues to become involved in learning activities that lead to authentic assessment. He expresses his frustration at feeling as though he is working in isolation. "I think we haven't as a group come to a shared consensus of what we are trying to accomplish" (Interview Transcript, May 19, 1998). Luke reported that this sense of isolation was not fully alleviated by moving to a grade eight setting. He suggests that perhaps teachers need to experience and explore mathematics themselves in a problem solving setting to better implement problem solving in their classroom. Further he suggests that "You really have to believe in what you are doing!" to make this focus on problem solving activities work.

4.5.6 Summary

Luke is very concerned that students develop a conceptual understanding of mathematics through problem solving. He also believes that authentic assessment requires authentic mathematics and thus promotes mathematics in a realistic context. Luke is a reflective teacher who would call himself a constructivist; that is, he believes that students construct their own meaning of mathematics through their engagement in activities.

Luke's experiences of teaching both elementary and secondary school mathematics allow him to see the teaching and learning of mathematics from different perspectives. He feels that the secondary school mathematics curriculum is entrenched in content and he appreciates the autonomy of teaching grade seven and
eight as well as the holistic approach that can be taken in the elementary school setting. Major stumbling blocks for Luke include a sense of isolation from his colleagues and at the secondary level, a frustration with the focus on mathematical content rather than mathematical understanding.
Chapter Five

Analysis and Interpretation of the Data

This chapter will focus on several common themes that have emerged through an analysis of the data. Initially, the chapter will include a summary of what the participants were doing as well as a brief discussion of their reasons for using authentic assessment activities. The chapter will then highlight dilemmas that the teachers faced as well as how the teachers dealt with those dilemmas. These include the disparity of striving to cover the content in preparation for an exam while also developing understanding through meaningful activities; the teachers' feelings of isolation as they make choices that differ from their colleagues'; and the difficulty of fitting a rich array of data gathered through authentic assessment into a traditional reporting system of assigning a numeric grade. The chapter will conclude with a summary of means that have been developed or may need further development to promote the professional growth of these teachers in their expertise in the area of assessment.

5.1 Summary of Common Activities

There are several areas that are common to all five of the participants. First, all five participants have decided to include authentic assessment activities while working in a fairly traditional mathematics curriculum setting. Their current teaching style therefore is dichotomous. At times, they employ a traditional approach
of giving examples at the chalkboard followed by students practicing the skill through drill. Other times, they engage students in active problem solving that focus on developing mathematical understanding, presenting mathematics in context, and encouraging communication about mathematics. The goal, in the second instance, is for students to increase their understanding and to make connections between mathematics, other disciplines, and their world. In developing these classroom activities the teachers are also developing methods of assessing the activities, most of which could be called authentic assessment. Thus, another commonality is that all of the participants are striving to link their new instructional practices with new assessment practices. These assessment methods also attempt to encourage the development of metacognitive skills, such as self-reflection, responsibility for their own learning, and self-confidence.

Each participant includes group problem solving activities as part of their classroom routine. Students are often presented with an open-ended problem that is given in a realistic context. Students are encouraged to investigate the problem and to determine and present a solution to the problem. The problem often incorporates recently acquired skills or is an introduction to a new set of skills that will be learned in a necessary circumstance. Such problem solving situations agree with the definition offered by Ginsberg et al. (1990) of problem solving situations as being active, conjecturing, modeling, and applying skills. Usually, students are given tools to help them solve the problem, such as manipulatives, chart or graph paper, graphing calculators and/or computers. As Franke and Carey (1997) suggest these
concrete materials help bridge the gap between formal and informal thinking for students. The solutions to the problems that are posed to students by the participants are presented in a variety of ways including written submissions with full justification for their answer, and presentations of the solution to the class, often using visuals or demonstrations. The participants assess these problem solving situations through observation checklists while students are working, rubrics to determine levels of performance of a written submission, and teacher or peer assessment of classroom presentations.

All teachers demonstrated an intrinsic link between the types of activities they were doing and the assessment strategies they were using. The assessment and instruction were bonded (or blended) together. Teachers were choosing activities to enhance the student’s learning and the assessment grew out of the nature of the tasks that they were asking students to do. “You plan an activity and then you decide how it would be best to assess it.” (Julia, Informal Discussion, January 23, 1999). Thus, as teachers develop activities and corresponding assessment strategies, the assessment that regularly appears can be identified as an authentic assessment strategy. Similar results were reported in several studies (Lehman, 1995; Kulm, 1994). New instructional practices necessitated new assessment practices.

When I began the study, several of the teachers were not sure that they were using authentic assessment and wanted to know it’s definition. In a focus group discussion Miriam said “I’m not sure that I fully understand what is the definition of authentic assessment” (Focus Group Interview, November 4, 1998). Then Miriam
revealed that she researched authentic assessment in a book on assessment and found that journals, portfolios, learning logs and other self-assessments were included and she recognized that she was doing authentic assessment.

Those are things that I do all the time without even thinking of them. . . . Those are things that are always included with our assessment. Self-evaluation, and so on. (Miriam, Focus Group Interview, November 4, 1998)

The development of reflection and self-assessment is also important to the participants. This is shown through the development of portfolios by Gwen, strategic planning by Luke, learning logs by Miriam, and journals and questioning by Dave and Julia.

Authentic assessment practices are used throughout a variety of grade levels. However, the teachers report that it is often easier to use more open-ended approaches in grade nine and ten because of the openness of the students and the fact that students are not as focused on marks as in the senior grades.

They may say “You haven’t done an example like this one”. And I find that it is the senior grades that are much more resistant to that than the junior grades. (Julia, Focus Group Interview, November 4, 1998)

The junior grades don’t mind playing with things and being wrong and trying again but the senior grades declare “Just tell me how to do the question.”

5.2 Summary of Why These Teachers Do What They Do

It is important to note that none of the participants had been mandated to use authentic assessment in their classrooms. Gwen and Julia are at a school where the grade nine reporting is not a traditional mark but rather, is a checkmark on several different outcome scales. Consequently, the nature of the report card encouraged
them to use rating scales to assess several outcomes in their grade nine program. All of the teachers in the study had been exposed to a variety of assessment strategies and problem solving activities through their own professional development, reading, and voluntary attendance at workshops and conferences. The choice to use authentic assessment activities was made by each individual teacher.

The reasons for using authentic assessment were woven through all of the interviews and focus group meetings and it appeared on the surface that there were several different reasons why these teachers included authentic assessment in their pedagogical repertoire. These include the importance of applying mathematics in real contexts, creating connections between mathematics and the student's world, developing problem solving skills, creating a deeper understanding of mathematics, developing metacognitive skills, and encouraging students' responsibility for their own learning. While these intents will be presented as separate ideas, they are firmly woven together. For instance, a teacher provides students with a problem solving application of mathematics in a real context with several purposes in mind: to deepen a student's understanding of mathematics, to help the student make connections, and to help the student build confidence in himself or herself as a problem solver.

One of the reasons for using authentic assessment activities that was cited by several of the participants is the belief that mathematics should be applied in realistic contexts to deepen students' understanding of mathematics and for students to recognize the value of mathematics. Students need to see the applications of mathematics within the classroom to be better prepared to apply mathematics outside
of the classroom. Miriam suggests that “It is the math that people are going to use in their lives” (Focus Group Interview, November 4, 1998). Mathematics must be more realistic and help students see its use.

During a focus group meeting (November 4, 1998), when the group started the discussion by questioning what is authentic assessment. I was a bit disheartened. It was the ninth month of the study and it appeared as though they were not clear about what constitutes authentic assessment. However, the discussion that ensued brought forth several key points. Luke insisted that you cannot have authentic assessment unless you have authentic mathematics. He describes his impression of authentic mathematics:

For me the notion of authenticity is “Is the mathematics you’re doing actually authentic mathematics?” Or is it just an isolated topic. And is the teacher as leader telling kids what to do? Or is it a chance to explore? Are they behaving like true problem solvers? Is the stuff that we are assessing even authentic, never mind the techniques that we are using. So can you have authentic assessment with a traditional type of curriculum? (Luke, Focus Group Interview, November 4, 1998)

The participants all used mathematics in a real context in problem solving activities. Julia used the “camping problem” to maximize area. Miriam had applied mathematics to the investigation of wind chill, finding a murder suspect, and optimizing profit with “Mama Mia”. Luke’s students analyzed shampoos. Dave investigated applications of linear programming such as transportation and communication. Gwen set up patio building companies with her grade nine students to explore measurement, patterning and algebra. Although these problems are not those that a grade nine student might naturally encounter in the course of an average
day, the problems illustrate how mathematics could be applied in a familiar and realistic setting. As well, the participants frequently discussed the problem with the students, linked the problem to other contexts, and in general, considered how the problem could be extended. Thus, all of the participants made mathematics authentic by placing mathematics in a real-life context. These results agree with similar studies (Mitchell, 1992; Ryan, 1994) that reported a greater emphasis on contextualized knowledge when new assessment programs were implemented.

Developing problem solving expertise was also seen as an important reason for choosing authentic assessment activities. Problem solving often grew naturally out of the mathematics in context or an application of mathematics. For these teachers, it was not only important that students could perform mathematical algorithms such as solving quadratic equations or use matrices to solve linear systems. It was equally important that they could take a realistic problem and interpret it in such a way that they could build a mathematical model to solve the problem. This model could be algebraic, graphical or geometric in nature. The leap between a problem in context and a mathematical model of the problem is often the most difficult one for students to make, especially if they are accustomed to mathematics in isolation. Yet, it is a significant one if they are going to be able to use mathematics outside of the classroom and see its relevance. This leap is also the crux of what these teachers call problem-solving.

But what we are saying is that modeling math is terribly important. And that everything you do in math is modeling. (Miriam, Focus Group Interview, November 4, 1998)
However, for students to solve problems they require an understanding of mathematics and these participants are striving to develop that understanding. NCTM (1989) suggests that students at the secondary school level should "use . . . problem-solving approaches to investigate and understand mathematical content" (p. 137). Many of the participants use cooperative learning strategies to provide students with the opportunity to solve problems, explain concepts to one another, and to encourage mathematical communication among students.

It's interesting to see the reaction of people. Some of the problem solving . . . People are surprised that I let students work in pairs and I say that generally in the work environment you won't work in isolation. (Miriam, Focus Group Interview, November 4, 1998)

These teachers hold the view that students reinforce their understanding of concepts through verbalization of those concepts. Gwen and Julia often use "Think-Pair-Share" as a method of review. In "Think-Pair-Share", one student teaches the other how to do the first question, then the roles are reversed for the second question and the process continues through the set of questions. As students are communicating with one another, the teacher circulates around the room and prompts where necessary. Gwen and Miriam discuss the benefits of students working together and conferring about mathematics.

Gwen: We really need to give them the opportunity to present things orally. Which they don't [normally do]. And they also need to write. I have kids do a lot of pair work where they have to explain to each other. "Explain to your partner how to do this question." If they [students] verbalize it, they understand it better.

Miriam: Well, all kinds of research shows that if you tell someone else how to do it then you learn it better. (Focus Group Interview, November 4, 1998)
Problem solving gives students an opportunity to explore and investigate mathematics. It also provides a forum for students to develop communication in mathematics and to develop problem solving strategies.

The participants also believe that developing a student's confidence in mathematics is important. It is a reciprocal arrangement because students need confidence to tackle difficult problems, and in turn, success at problem solving builds confidence. Students require confidence to take necessary risks in problem solving such as trying a different approach, brainstorming or using trial and error. However, teachers also see that by engaging students in open-ended problem solving where there is not necessarily only one correct answer and the teacher is open to alternate solutions, then the students develop confidence in themselves as problem solvers. Thus, problem solving both requires self-confidence and develops self-confidence. As Schoenfeld (1992) reported, students' beliefs and attitudes about learning mathematics affect their understanding. The development of metacognitive skills supports the development of problem solving skills.

Participants reported that a surge of confidence was not an immediate reaction to using authentic assessment activities. In most cases, where students have been taught in a traditional style, there is an initial period of discomfort for many.

I find that a lot of the senior students start to really get to the point where they are just memorizing how to do things rather than thinking about what they are doing. (Julia, Interview transcript, May 2, 1998)

There was also a discussion about this issue of students being inexperienced and uncomfortable with open-ended problem solving in the first focus group discussion:
Miriam: Don't you find that it is also that students haven't had any experience in being given open-ended problems. Because they are so used to problems that have an answer.

Gwen: I know "I don't get it. I don't get it." That's the first thing they say.

Miriam: They want to be told what to do. I mean I even find this with my OAC classes. They say "Just tell me what to do." (Focus Group Interview, November 4, 1998)

This initial discomfort disappears as students become more aware of what is expected of them and become more comfortable with approaches to authentic problem solving.

Miriam: Once you sort of go over it with them later then you can say this is sort of what I was looking for. Then they get better. They say "Oh, that's what you mean, that's what you wanted." ... That is sort of what happens when students get used to us giving them the right answer. ... I mean I think it's not so much the students who need to change but it's the teachers too.

Julia: We have to give them examples of what is up here (gestures a high level with hand) and what to strive for.

Miriam: It's amazing what they can do when you give them your expectations. I know with my grade 12's this happened.

Luke: I did a performance assessment about 3 weeks ago and it was really the first one I had ever done. I was shocked at how well it went. ... What was interesting was that some of the kids needed coaxing to get going but once they got going they just took off. So often the kids don't get there because they are not allowed to look things up or to ask for help. It was so powerful and I was really pleased with how well the kids did. I wanted to share that as an encouragement. (Focus Group Interview, November 4, 1998)

Gwen used several activities to encourage self-reflection and build self-confidence. Her use of authentic assessment encouraged students to be successful at mathematics and to take responsibility for their own learning. Her activities were not as open-ended as some of the others and had quite a bit of teacher direction.
Authentic assessment allows the teacher to see the student as a whole person. Several of the teachers found that you would often have students involved who did not usually get involved when the class was organized in a more traditional manner. Dave uses journals to get to know the whole students and to give the student an opportunity to feel valued.

Teachers are using authentic assessment and their linked activities so that students will develop a deeper understanding of mathematics, will see the relevance of mathematics, will be able to apply mathematics to solve problems in other contexts and will develop the confidence and skills necessary to make use of the mathematics that they learn. The reasons why the participants are choosing authentic assessment activities fit with the NCTM (1989) "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" (p. 5).

5.3 Dilemmas

When interviewing participants, I asked them about the stumbling blocks, dilemmas, or constraints they encountered. There were many similarities among participants in their responses to this query. The discussion includes their perceived dilemmas of time constraints in trying to cover the content or the skills of the course while also injecting authentic assessment activities that they felt were important. This also lead to a pedagogical dilemma of juxtapositioning what an exam required them to cover with what they thought it was important for them to do in a classroom to
help students understand mathematics. Another stumbling block was their feeling of isolation and estrangement from other members of their department because of the types of activities they advocated. And a further dilemma was that they recognized that they had to deal with how to incorporate data gathered from authentic assessments with data gathered from traditional evaluations and put it together to report in a traditional manner.

5.3.1 Setting Authentic Assessment Activities in a Content Laden Curriculum

All five of the teachers were trying to combine the traditional course content and traditional testing with other activities which were generally problems-based or self-reflections on the students' own learning, and assessed using authentic assessment strategies. These teachers cover prescribed content so that they can ensure that students are well-prepared for the exam. Frequently, these teachers question the importance of the prescribed content and feel as though there are other, more significant mathematics concepts that should be experienced. The participants are doing activities that they believe will give students a deeper understanding of mathematics, help them make connections to mathematics, and allow students to take responsibility for their own learning. They are also covering the prescribed, more traditional curriculum.

One critical dilemma for the teachers is how to cover all of the prescribed content and still have time to do the activities that they felt are most worthwhile. "Covering the content" is the term that teachers use to describe the pressure that they feel to "pack in" many distinct (sometimes seemingly unconnected) topics that have
been designated as part of the mathematics curriculum. The pressure to cram so many topics into so little time often forces teachers to teach mathematics as a series of memorized algorithms rather than to strive for student understanding of mathematics. The experiences of these participants appears very similar to the experiences of the participants in the study by Rowley et al. (1996) where he reported that the participants felt pulled in two directions.

The participants see this dilemma as a time issue because they do not have time to cover the content and do the interesting things that they think students should do. An alternative interpretation of their dilemma is that the issue is not necessarily time but it is teaching a curriculum that they are not convinced is totally valid. Thus, they are attempting to inject mathematics that they believe should be taught, and instructing and assessing this mathematics in a style that they perceive as authentic. The problem for them is how to incorporate more of what they believe is valid into what they perceive they “have” to teach.

The participants point to several consequences of dealing with this dilemma. One decision that each participant had to make was how to blend the content with the problem solving activities. Another perspective they took was that mathematics education was in transition from a content oriented curriculum toward a problems-based curriculum and in due time the curriculum would be problems-based yet cover the content in the context of the problem. In fact, several of the participants feel that they could create such a curriculum, given the time to create and implement it. A
third issue is that exams drive what is being taught and how it is being taught and perhaps the format or purpose exams should be reconsidered.

The participants also feel that to effect an authentic or problems-based curriculum rather than content-based, the teacher needs to be very confident and knowledgeable about mathematics to meet the challenges of the students as they move through investigations and explorations. It was also pointed out that the teachers had more difficulty enhancing the content of senior level courses with open-ended problem solving and authentic assessment because the courses at this level are so content-laden that it is not possible.

A content based curriculum is seen as pressing in a prescribed amount of time into a short period of time with little room for exploration and investigation.

Because they [other math teachers] perceive it as taking time out of that well laid-out schedule that they have of cramming x pages of curriculum into the kids heads... This content approach is the biggest stumbling block. There are people who I think would try stuff but they see it as taking away from the primary focus which is to cram all of this content in. (Dave, Interview Transcript, October 1, 1998)

These teachers approach combining the content of their courses with authentic activities in a variety of ways. During certain units, the teacher may begin the unit with a problem in context so that the students may see the purpose of pursuing a set of skills that will help them determine the solution to the problem. At other times, the teacher may first teach the content and then use problem solving activities as a follow-up. Julia mentions that she sees a dichotomy between learning the rules and then applying them to an activity.

If I feel that I'm just teaching the unit and the kids are just doing all the rules and I think that's kind of the way the unit is set up then I try to
take the time to find an activity or something that will enhance that and make them think a little bit more. Because I think it helps them learn. It helps them become better students. (Julia, Interview Transcript, January 14, 1999)

However, the teachers find it difficult to have enough time in a course to do all that they want to do. Miriam refers to abandoning journal writing with her students because it became an overwhelming task.

So the journal writing has gone. But that is a reality of being a non-semestered school. There are years when I am teaching 170-180 students and I am finding it impossible to keep up with it so it has become intermittent. Portfolios - yes. I still do them particularly with the younger grades. I would love to extend it to the older grades but just run out of time. And I would think that is the major complaint of teachers. There is so much more you would like to do but you only have a certain amount of time. It is better to focus on a couple of things and hopefully do them well. (Miriam, Interview transcript, June 30, 1998)

Several of the participants suggest that this dilemma could be solved if there were a curriculum that embedded the skill development in a problem solving context. This would mean a complete rewriting of the curriculum. Julia expresses her vision of what the curriculum could be:

I want to start from scratch, sit down with somebody and completely change the way we teach grade 9. I sort of picture what I would do. I want to do many more activities, much more discovery, much more group problem solving. I would love to do more projects as they are learning different skills as they work through the project, not so much a topic by topic approach. This means revamping the entire way we teach the course. (Julia, Interview Transcript, January 14, 1999)

Dave is hopeful that the upcoming changes in the mathematics curriculum will help to alleviate the problem. The participants view themselves in a state of transition. As with several other studies (Shepard, 1994; Flexer, 1995; Borko, 1997; Ryan, 1994)
teachers reported making curricular changes such as re-sequencing curriculum, introducing new concepts, and emphasizing process rather than content.

However, the participants worry that they may not be able to implant all of the necessary skill development in contextual problems.

I want to go to the other, but I’m afraid that I’m going to miss all the skills that they need to solve the problem. I know some of the literature is saying, ‘give them the problem and the other will evolve through it’. I think that it’s just that I don’t have enough experience in that. (Gwen, Interview transcript, April 23, 1998)

Several of the participants felt driven to cover the content so that their students would be prepared for the final examination. Julia believes that problem solving and authentic assessment activities are important but she does not want the time spent on those activities to be time taken away from examination content which might disadvantage her students’ success. Gwen suggests that teachers see the examinations as “driving the curriculum”. Miriam and Luke also express the opinion that mathematics courses are driven by the exam and teachers view their role as preparing students for the examination. Miriam indicates that the examination keeps all of the teachers at the same point at the same time. The common examination in a course forces teachers to teach skills at a certain point in the course and in a certain way. The commonality of the content encourages a commonality of approach by all teachers. Miriam suggests that this does not necessarily allow for the spontaneity that a problem solving curriculum suggests.

Well, it [the examination] is just a way to keep everyone coordinated. So that everyone by a certain date has covered the same material and that sort of thing. However, if you do a legitimate problem in class, then I think you have to be prepared for where it will lead you and sort of deal with the math as it comes up. And it may be something that should
come up second term and that's a problem because we have so many
time constraints about having certain things that have to be covered by a
certain time because of our evaluation. (Miriam, Focus Group Interview,
February 11, 1999)

This is supported by Neill and Medina (1989)

As teaching becomes "coaching for the test" in too many schools, real
learning and real thinking are crowded out. Among the instructional
casualties are higher-order thinking skills. (p. 694)

Miriam suggests that a solution could be to have exams disappear. Dave would like
to see the final examination take a completely different format. Several of the
participants offered alternatives to traditional examinations, including performance
assessment tasks as summative assessments. Dave’s department created an in-class
examination component that incorporated technology. Dave also had experience with
a group final examination.

A colleague and I used that over at Northern Secondary School [one of
Dave’s previous schools]. We both had grade 9 general level classes
and there was no way that they were going to sit through an hour and a
half exam. . . . So what we devised was a half hour of a traditional type
exam and then in the middle half hour we put them in groups of 3 or 4
and they had these experiments they had to do. One was throwing darts
at a dart board, another was something about unit costs - we had cans
and juice boxes of various sizes. And then back on their own again, they
had to analyze and present the data in one form or another, whether it
was graphically or in a chart or whatever. We did it mainly because we
didn’t think that they could sit for an hour and a half, but the results of
that were really, really positive. (Dave, Interview Transcript, October 1,
1998)

On a more global front, the Education Quality and Accountability Office
(EQAO) in Ontario has been piloting performance assessment in grade nine
mathematics. Several of the participants have mentioned these as prototypes for
summative assessments. As well, several of the participants have developed tests which include open-ended questions that may be marked with a rubric or checklist.

Another aspect of the content driven curriculum is that for many teachers it is very appealing. If the teacher is in control of the content of the course then the teacher does not have to fear questions or problems arising that the teacher may not be able to answer. In a Focus Group discussion, Miriam suggested that a problem solving curriculum could lead in many different directions. Luke suggests that teachers would need to be comfortable with a more open-ended approach.

It means that you need a great knowledge of the course. Even an experienced math teacher, unless they know the course well and can see connections that can be made and can be drawn out would have a hard time. So you need to know the course and you need to know the mathematics. (Luke, Focus Group Interview, November 4, 1998)

This restates what previous studies (Grossman, 1992; Thompson & Thompson, 1996; Roulet, 1998; Goldin, 1990) have said about the importance of a teacher’s beliefs, attitudes, and mathematical knowledge. Because many of these participants’ colleagues are comfortable with the content driven curriculum, it makes it more difficult to create a common curriculum and to change common assessment practices. This often leads to isolation which will be covered in a latter section of this chapter.

While most of the participants readily included problem solving activities, portfolios or journals, and other authentic assessment components into their grade eight or grade nine curriculum, it was not as easy a task to do at a more senior level. Dave used group problem solving and journals with his senior students and Miriam used performance based assessment with her grade eleven and OAC students.
However, Julia and Gwen expressed concern about their focus on grade nine and the difficulties they had including authentic assessment activities in grade twelve classes.

In summary, the participants are caught in the middle. They find it necessary to teach a traditional curriculum to prepare students for a traditional examination. However, they would prefer to teach authentic mathematics to prepare students for the world.

5.3.2 The Problem of Isolation

The participants often spoke of feeling as though they were working in isolation, or worse, seen as the "odd person out". These participants see themselves as doing things a bit differently from their colleagues and they perceive that their colleagues see them that way as well. This section will address the participants' feelings of isolation, the participants perceived rationale for their colleagues' disinterest in authentic assessment, suggestions for engaging colleagues in authentic assessment, issues of consistency in assessment, and the need for collaborative work.

The participants' feelings of isolation are very strong. Feelings of isolation were not reported in previous cited studies. However, in the previous studies, the participants were generally part of a group that was implementing a new initiative. In this study, however, the participants spoke of being hesitant to share their ideas because they feel as though they may have to be on the defensive or be prepared for criticism. Julia mentions that:

To a large degree I don't tell people what I'm doing or I'll wait until I've done it and see whether or not I really liked it before I tell them. But if it is something that I think went well and I think is worthwhile then I share it. (Julia, Interview Transcript, January 14, 1999)
All of the participants expressed similar concerns. These teachers feel like outsiders to their own department and often receive negative feedback when they share some of their ideas. In a focus group meeting, Gwen reported that:

I said to one person in my department that I had done a self-evaluation at the end of a unit and they said “Oh, I used to do that and try to relate it all to the report card but in the end I am going to give them the same check mark anyway so it doesn’t really do me any good.” They seemed to miss the point that it was the kid who was going to get something out of the self-evaluation. (Gwen, Focus Group Interview, November 4, 1998)

The interesting aspect of this is that when Gwen reported this to the focus group of participants, she actually received very positive feedback from the group. Dave reported that Gwen’s respondent must not have been able to “translate that into a mark”. So, although Gwen’s colleagues were skeptical, she received positive feedback from her focus group on reporting the incident. Luke often expressed his frustration at feeling “different” from the rest of his department at the secondary school level. Although Luke reported that he had more time at the elementary level to try innovative ideas, he also reported that he still felt isolated. Other teachers were not attempting to implement the curriculum in the same way that he did.

Even though these teachers are feeling isolated they still continue to try new things in the classroom because they believe in what they are doing. They see these experiences as part of their professionalism and often wonder or become frustrated that other teachers do not see it this way as well. The question arose “Why are the other colleagues so suspicious of these ideas?” Dave suggests that: “Even the young teachers have old thoughts” (Interview Transcript, October 1, 1998).
These forms of assessment may be difficult for many teachers because they may not feel comfortable enough with the mathematics to venture into open-ended problem solving:

They are math teachers but they are not [math teachers], because they don't have a strong math background. I don't think that they have experienced math that way themselves and it is a pretty huge task. (Luke, Interview Transcript, May 19, 1998)

When the teachers shared their ideas with others in their department, they occasionally had experiences of shifting teachers' views of authentic assessment activities by giving them samples of activities that they had tried themselves. Miriam had an experience of teaching one of her colleagues a different way of teaching integers to grade nine students, using bingo chips.

I know I had a teacher last year and I showed him how to teach integers using bingo chips and this guy finally tried it because I said that I am going to put a modeling question on integers using bingo chips on the exam so you will need to do it with his students. Well, there was a lot of grumbling and commotion and he tried it and then noticed that the kids were flying through the questions. He was sold on the idea. He fought for years and then tried it and was so excited and loved it. (Miriam, Focus Group Interview, November 4, 1998)

As a new department head, Dave feels frustrated about getting his department on board as indicated by this discussion between Dave and Luke. Miriam, also a new department head, suggests that one way to start to move people is to mandate some changes to the final examination, since most teachers focus on what students need for the examination. Dave mentioned that he has also attempted to mandate some changes by changing the nature of the final examination for all courses to include a technology component worth 10% of the exam. At our final interview, after first semester examinations, Dave reported that this technology component had a very
positive effect on the use of graphing calculators in classes. Most of the participants agree that the best way to move people is to start by giving them samples of assessment activities that are moderate adjustments to what the teachers are already doing. The teachers need to see the activity as manageable and of benefit to students.

Convincing people here of the value of a lot of this is really tough. One lady who started doing some math journals is all excited about it. Now, she never said, "Well, Dave is doing them so I am doing them." But that's great. I don't care why she is doing them. (Dave, Interview Transcript, October 2, 1998)

Luke suggests that teachers need to share ideas in order to develop new strategies. Yet Luke warns about being sensitive to other colleagues and not forcing authentic assessment as the "answer". The participants feel that what they are doing has value, yet they don't feel that they are in a position to justify it to others nor do they feel that there is research or an "authority" to suggest that this is the best way.

One problem with isolation is that it can lead to a lack of consistency in assessment. The reality of some teachers incorporating new teaching and assessment strategies while others are not, creates issues of incongruity, incoherence, and questionable accountability. Several of the participants recognize that there is a wide gap between colleagues about issues of assessment and this concerns them.

Gwen believes that it is important that teachers discuss criteria for assessment and she brings forth the need for professional development and discussion among teachers to determine criteria for placing students at different levels in the report card:

I think, as a department, we've not outlined what the criteria is for each level. There are a few people who believe in it, one or two, and a couple people who are going with it because that's the way it is, but aren't really spending the time, like there's not a lot of discussion on it. They
don't want to discuss it, they think it's "hokey" stuff. (Gwen, Interview transcript, April 23, 1998, p. 6)

She also remarks on the reluctance of some teachers to adhere to this system of assessment and reporting.

As supported by several studies (Morony & Olssen, 1994; Rowley, Leder & Brew, 1994; Rowley et al., 1996) teachers need to be supported and provided with informal opportunities to discuss and debate issues. If teachers are going to increase their expertise with authentic assessment then teachers need to talk about their experiences. Most of the participants recognize that this should be given administrative support and assistance. One example of the encouragement that teachers gain from talking about assessment strategies was brought forth in a discussion in one of our Focus Group Interviews. Dave began the discussion of an example of an open-ended test question and Luke expanded the idea by describing one of his test questions that I will refer to as "Convince me". This is how the discussion unfolded:

Luke: I once gave a test [in Calculus] that said "Convince me that you understand this topic."

Miriam: I like that. I think I'll try that.

Julia: That's great.

Gwen: They'll always come up with great stuff. I always have kids make up a question on their unit test. And the questions they make up are harder than anything than I put on there. And they do them and get them right except for the simple careless error.

Miriam: What was it again that you asked, Luke?

Luke: Convince me that you understand this topic.

Miriam: I like that. That would be great.

Dave: I use a similar approach in a business class. Where they each wrote out a question, I collected them, shuffled them up and there was
your test. They really like that. "Oh, there's my question, there's my
question." It may be impossible but there it is.

Gwen: Even using a written test, there are still lots of things that you
can do on a written test that are more authentic. (Focus Group Interview,
November 4, 1998)

I had several more interviews with participants after this focus group session and I
was surprised to find that each of the participants referred to this "Convince Me"
story and used the concept in some way in one of their assessments.

Miriam mentioned in her post-observation interview (November 26, 1998) that
she shared Luke's "Convince Me" test question with her whole department and they
discussed the idea and thought that there were many instances where they could use
it. Dave used the "Convince Me" idea as a follow-up to the investigations of
applications of matrices that I had observed in his class. He gave the instruction
"Convince me that you know about traffic problems" in a journal entry. I asked him
how it went at our final interview.

A lot of them just used an example. They might have made up their
own example but nonetheless, it was just an example... But as I said to
many of them, that convinces me you can do it. It doesn't yet convince
me that you understand it... So we talked after that about how to build
an argument. What do you offer as supporting proof? What kinds of
information do you put in, what do you leave out? Those kind of things.
I think it was a good exercise... You know what's kind of neat was
that on the final exam I put another one [Convince Me question] on.
Convince me that you know binomial probability and that was done
much better. (Dave, Interview Transcript, February 2, 1999)

Julia used the "Convince Me" idea as a starting point for a group activity with
grade nine students. "Convince me that \( \frac{1}{2} + \frac{1}{3} = \frac{5}{6} \)." She encouraged students to use
models or applications to explain why this is so. She had found that the students had
relied so heavily on algorithmic methods of adding fractions that they had either lost or not fully understood concepts about fractions. Luke used the "Convince Me" idea in conferencing with students while they were working on project. Everyone seemed to have taken a simple idea and adapted it to their own purpose.

In fact, Miriam suggested that our first focus group interview energized her. She believed that the discussion was very stimulating and commented that: "Teachers just don't have enough time to talk to one another" (Informal Interview, November 13, 1998). Dave suggested that the assessment group that was meeting the previous year was very successful. Gwen and Julia often work together in their department and develop and share activities together. Thus, working with someone else helps. Collaborative work between teachers shares expertise in areas of assessment and also through discussion, consistency of assessment is developed.

5.3.3 Authentic Assessment and Reporting

Several of the teachers discussed the difficulty of matching authentic assessment techniques with a more traditional method of reporting using percentage marks. The data gathered through authentic assessment frequently consists of levels on a rating scale or rubric, or is anecdotal. This type of information is unsuited to being directly translated into a percentage mark. Wiggins (1994) confirms the dilemma of translating rich assessment data into a mark or grade for a report card.

Why, then, do we arbitrarily average grades and scores in school - where the dimensions of performance are even more complex and diverse - to arrive at a single grade per subject? Problem solving is not research, is not writing, is not discussing, is not accuracy, is not thoroughness, is not mastery of the facts. And, why do we compute averages over the course of a year? One is either achieving at a certain
level, or one is not. Why would we use your earlier grades, for example, if you are now performing at a higher level? (p. 35)

This section will discuss some of the difficulties and will describe methods of reporting that the participants found helpful.

All of the participants found it difficult to convert authentic assessment to a mark in the other grade levels. Gwen mentions:

I think the hardest thing right now is, except at the grade nine level, trying to relate authentic assessment to a mark, in the other levels, that’s where I find I’m having a little bit of difficulty, and even though the kids have no trouble evaluating that way, they don’t seem to want to know what their mark is. (Interview transcript, April 23, 1998)

Julia also had difficulty using authentic assessment with her more senior grades compared to grade nine where the report card is in levels. Julia uses authentic assessment in her grade twelve class and then attempts to convert that assessment data into a percentage mark.

Using reporting methods that relate to levels definitely makes it easier to adapt authentic assessment to the evaluation of students. Luke uses levels of achievement with his grade eight class, and Gwen and Julia report achievement with checkmarks on a rating scale for their grade nine classes. These three participants all believe that it is easier to link assessment and the reporting of progress when the emphasis is on levels of achievement rather than strictly a percentage grade. Luke’s grade eight students receive a percentage mark on their report card but Luke contends that since the students have been using only levels of achievement (and not interpreting them to percentage marks) that the thinking will still be in levels. However, Luke mentions
that some teachers are confused with the use of a dual system of percentage marks and levels of achievement. Gwen agrees with the confusion:

If teachers are required to report in levels then I think they will use marks and they may translate in reverse by taking the mark back to the levels rather than the levels to the mark. They may have some difficulty with that, because I think a lot of people, paper and pencil tests will still be used. (Gwen, Focus Group Interview, November 4, 1998)

Gwen believes that students and parents receive more information from a report card that discusses levels of achievement on several different outcomes rather than a percentage mark. She is a firm advocate of this method of reporting and believes that parents and students could be as well. Julia also believes that the grade nine report card is useful to students:

But I think just in terms of feedback to students, I think it's really helpful rather than just giving them a mark. I think it is good to continue to mark things in this way. Maybe I should be doing that more with my grade 12 class. Maybe I should give them more anecdotal information about where their strengths are and where their weaknesses are. (Interview Transcript, January 14, 1999)

Julia further remarks that the set-up of the grade nine report card actually encourages her to use other forms of assessment rather than paper and pencil tests.

5.4 Making Authentic Assessment Better

This section will discuss several points that arose from this study that appeared to enhance the quality of authentic assessment practices. These include the role of partnership of students and teachers in being more aware of authentic assessment strategies, increasing teacher resources about assessment, enhancing teacher development, and lending administrative support. Several of these points were suggested in research by Wiggins (1992)
Constraints facing the designer of authentic assessment tasks typically involve access or restrictions to the following resources: (1) time (including time to prepare, rethink, and revise), (2) reference materials, (3) other people (including access to peers, experts, the test designer, and/or the judge), and (4) prior knowledge of the tasks and how they will be assessed. (p. 27)

5.4.1 Partnerships

The participants felt that collaborating with their colleagues as an aid to developing expertise and increasing consistency in assessment was very important. It is also important to increase students’ and parents’ awareness of authentic assessment and to share with them the purpose of new instructional and assessment strategies.

Lester and Kroll (1990) suggest that:

Assessment methods communicate to students (and to parents and administrators) what is considered important. And having an assessment method in mind also helps teachers be sure that they are including in their teaching those aspects of problem solving that they value. The assessed curriculum strongly influences what students are taught and what they value. (p. 68)

Several of the participants related negative student reactions when authentic assessment is initially used. The following is part of a focus group discussion:

Miriam: I find that some of the kids who fight against this stuff just want to know if they are right or wrong. They want you to tell them exactly how to do it and then let me plug in the numbers and get the right answer too.

Luke: Well, they have always been rewarded for that method. I mean “I can’t get a 100 in this sir so my parents will be mad.” For some parents, that’s the objective of evaluation - for their student to get 100%. (Focus Group Interview, February 11, 1999)

Marks are very important to senior students and their parents because high grades are the “ticket” to admission to the university of their choice. Therefore, it is
understandable that students become anxious or uncertain about teachers' use of something that is unfamiliar to the student.

I had an OAC Finite student who was upset with one of the questions that was given on an assignment because it wasn't exactly like one that had been done in class. And he took great exception to that. We talked about how this one was different. Kids have trouble recognizing that they need to interpret and think about a question. They want to be told what to do. I mean I even find this with my OAC classes. They say “Just tell me what to do.” (Miriam, Focus Group Interview, February 11, 1999)

In a recent study by Roulet (1998), similar concerns were expressed:

I and other experienced mathematics teachers have found that senior, university-bound secondary school students, responding to the demands of high grades, often lose their interest in working to understand concepts and demand direct fail-safe routes to correct answers. (p. 95)

Thus, the whole "system" has a tradition that supports the use of percentage grades.

The participants appeared sensitive to this situation and sought to involve the students in the creation of rubrics and discussions of criteria for assessment. This agrees with Stiggins and Conklin's (1992) comments about teacher sensitivity to the assessment of students.

Well-prepared teachers are aware of the fact that they are not the only decision makers who use classroom assessment results. Students use classroom assessment results to make very important decisions about themselves and to decide how they fit into the academic and social context of school and beyond. Competent teachers possess a frank and specific understanding of assessment from the students' point of view. They know how to help students develop self-assessment skills and they realize the personal dangers to students of unsound assessments on the part of their teachers. (p.181)

The participants also describe that students become more comfortable with authentic assessment as their familiarity increases over time.

Once you sort of go over it with them later then you can say this is sort of what I was looking for. Then they get better. They say “Oh, that's
what you mean, that's what you wanted." . . . That is sort of what happens when students get used to us giving them the right answer. . . . I mean I think it's not so much the students who need to change but it's the teachers too. (Miriam, Focus Group Interview, February 11, 1998)

Luke recognized that the students actually felt more relaxed with an authentic assessment activity because it alleviated the stress of a paper and pencil test where resources or communication are not allowed.

Several participants use exemplars (or samples of student work) that show students the type of criteria that are used to reflect a particular level of achievement. Miriam agrees with this notion as we discussed her work with her grade twelve students. Most of the participants discuss the assessment criteria with the students before initiating the assessment activity and often provide exemplars.

I tell them that I will be marking it and I tell them that they will be evaluating it as well. I talk to them about, or I usually write down on the overhead with them, "What would really make a good assignment", and some of the things that would tend to make a satisfactory kind of assignment and what would be something that would be considered to be not such a great assignment and we will write down together as a group some things to look for. (Julia, Focus group interview, February 11, 1999)

Some of the participants attempt to increase students' understanding of how authentic assessment applies to them by having the students help in creating rubrics for specific activities.

5.4.2 Resources

Several of the participants mentioned a lack of resources or the time to find and adapt resources as a major stumbling block to their use of authentic assessment. As well as resources for activities, teachers need exemplars of problems, assessment tools,
and samples of student work to assist them in determining levels of achievement.

Even when resources are located, they are not always suitable to a teacher’s needs.

I haven’t done a lot of rubrics, and the ones that I’ve used have been from literature or from the OAME stuff. A few weeks ago I used a rubric that was basically the question restated in a rubric form. It had different levels that they had to come up to and the rubric was made to match that. Creating rubrics, I think, is a real difficulty. And some of the problem solving rubrics that I have seen use descriptors like: “can do this question with minimal assistance” but I don’t know what minimal assistance is. Does this mean that they ask the teacher for help? I have difficulty finding the level for that one in particular. (Gwen, Interview transcript, April 23, 1998)

Miriam describes the lack of time to be able to find and develop resources. Julia often finds it difficult to create new activities to suit each unit and recognizes that she often needs a resource to stimulate an idea that she can develop.

Professional development or courses in authentic assessment are a possible way to help teachers locate, adapt, or develop resources. Dave suggests:

What would be good would be a course of some kind in this stuff. It truly would be. It would take people who were excited and kind of lessen their load a bit. I mean it is hard to keep recreating everything by yourself. And for people who haven’t tried it, it could be a relatively non-threatening introduction. I mean, if they could get some ready-made rubrics and activities that go with them then there might be a way to get them started. (Dave, Interview Transcript, October 1, 1998)

As a new department head, Dave recognizes that teachers have very little time to investigate and implement new assessment strategies in their classrooms. Gwen also refers to the creation of activities requiring a great deal of time. Luke reiterates the need for teachers to find time to share the resources and ideas that they have:

And we’re all doing it. What we need is time to share. (Luke, Focus Group Interview, November 4, 1998)
All of the participants mention that resources and time to find resources would be useful, for they felt a lack of adequate resources. And yet, each of the participants had given me several samples of activities that they used with their class.

5.4.3 Attitude towards Professional Growth

Throughout this study, I was impressed by the participants' high level of commitment to professional growth. For instance, all of the participants had gone beyond the mandatory educational training to partake in or complete Specialist courses, as in Dave, Julia, and Miriam's cases, or Master Degrees, as in Gwen, Luke, Dave, and Miriam's cases. The participants were engaged not only in lifelong learning but also in seeking new resources, adapting their teaching, and generally enhancing their professional expertise. It has been suggested that "Mathematics teachers need to continually explore mathematical concepts and ideas to be better prepared for different learning situations" (McDougall, 1997, p. 163). These findings are supported by the practice of the participants.

Examples of the teachers' commitment to professional growth occurred constantly. All of the participants attend workshops and conferences on their own time. For instance, Dave attended a week-long summer program to learn about graphing calculators. Several of the participants stated that they start each new school year with a pledge to themselves to try one or two specific new ideas, such as introducing rubrics or portfolios.

Sometimes I think I should maybe plan a bit to for instance, this year I am going to generate 3 more activities with rubrics, let's say. I do that. I commit myself to do that because I sometimes figure that if I don't do that then nothing happens. Because it is much easier to slide back into
the traditional or whatever you did last year. Whether it was traditional or not. It is much easier to slide back. (Dave, Interview transcript, October 1, 1998)

The participants demonstrate instances of being reflective practitioners.

A lot of what I think about is what can I do differently? What didn’t go well, what can I improve on. I often think okay, next year when I do this I’m going to do this, this way. Even sometimes I’ll make notes to myself after I’ve done an activity that this needs to be worked on or I’ll think of something like gee a great way to start this section off would have been. So when I go back the next year I have things to think through. I try to come up with. Well, it really depends. If there is something I think is lacking. (Julia, Interview Transcript, January 14, 1999)

These teachers are gatherers and adapters of ideas. They seem to see mathematics everywhere and adapt resources rather than use them directly. Participants gather ideas from a variety of resources such as other colleagues, conferences presentations, or print resources. Dave mentions finding ideas in articles such as the one he found in his chiropractor’s office. He also adapted a cartoon that he found in a newspaper on his vacation in Puerto Rico to create a probability distribution problem. The participants are willing to try new ideas and take risks. Gwen spoke of her willingness to try new things when she spoke of why she decided to use portfolios:

Again, it is just more experimental. I wanted to try something different and see how it works, if it works and to see the amount of work it requires from students and from me and to see if it is worth it and if it is manageable. (Gwen, Post-observation interview, November 23, 1998)

This willingness to take risks requires that the teacher be confident in mathematical knowledge and insight.

It means that you need a great knowledge of the course. Even an experienced math teacher, unless they know the course well and can see connections that can be made and can be drawn out would have a hard time. So you need to know the course and you need to know the mathematics. (Luke, Focus group interview, November 4, 1998)
It would appear as though the participants solve the problems of creating meaningful mathematics curriculum by taking on the characteristics they encourage in their students; risk-taking, confidence, collaborative work and the use of appropriate resources. These characteristics were previously mentioned in several studies (Brown & Baird, 1993; Carpenter & Fennema, 1991) as being strong influences on teacher's use of problem solving and authentic assessment activities. Luke notes that "You really have to believe[that this is the right thing to do]" (Luke, First Interview, May 19, 1998).
Chapter Six

Reflections

This study involved five secondary school mathematics teachers who chose to implement authentic assessment activities in their practice. It examined their beliefs, practices, concerns, and support over a one year period through extensive interviews, classroom observation, samples of their activities, log books, and focus group discussions. The teachers had firm beliefs as to why it was important to use authentic assessment and these beliefs included the view that mathematics should be set in a realistic context, developing thinking and problem solving skills is critical, understanding of mathematics concepts rather than memorization of algorithmic processes is essential, and the development of metacognitive skills will enhance students' learning. The participants' use of authentic assessment included checklists, peer- and self-evaluation, performance tasks, journals, and portfolios. These assessments were used in a variety of grade levels. The greatest dilemmas faced by the participants included balancing traditional expectations in the curriculum with authentic assessment activities, matching new assessment techniques with traditional reporting techniques, dealing with feelings of isolation and alienation from colleagues, and some skepticism about authentic assessment from students, especially in the senior grades. The most important resource for these teachers was time. This time includes time to find resources, adapt and develop authentic assessment activities, class time to include authentic assessment activities, and time to work with
colleagues who are having similar experiences. In this final chapter I would like to focus on what I see are the key messages of the study, limitations of the study, areas for further development and research, and my reflections on my experiences throughout this study.

6.1 Key Messages

I believe that part of my role as a qualitative researcher is to give my participants a voice. I would like to use this section to establish what I perceive as some of their key messages. As captured in Chapter Five, there are several outcomes that emerge from this study. The key messages that participants voice include the necessity for a problems-based curriculum, the importance of developing a collaborative teacher culture, and the important role that administrators can play in facilitating change in assessment practices.

If teachers are to move to more problem solving and authentic activities then curriculum must be developed that will facilitate rather than inhibit that movement. The teachers in this study were constantly torn between delivering a curriculum that listed content topics and assumed a traditional teaching style, and a problems-rich curriculum with a variety of teaching styles. If authentic assessment activities are to be implemented then a curriculum that encourages and promotes those activities should be developed. Teachers have difficulty teaching a dichotomous curriculum.

As well, a collaborative teacher culture needs to be supported and encouraged. This collaborative culture serves as informal professional development which helps teachers develop expertise, and share resources. It also helps to develop consistency
in assessment practices which leads to greater accountability. Through sharing, teachers also develop a system of support.

The feeling of isolation as teachers develop new initiatives has been reported in other inquiries. In a recent dissertation, Roulet (1998) examines the practice of exemplary mathematics teachers and his description of his participants, Randy and Jonathan, concurs with my experiences of the isolation of teachers:

Intellectually live mathematics teachers, those who are natural knowledge seekers, can, with effort, find collegial links that support their interests in furthering their mathematical understanding. The resulting explorations can help develop conceptions of mathematics that support changed instructional practices. The potential for such sequences exist, but the teacher effort involved is considerable. In the present environment of little or no support for intellectually adventurous teachers, the population of mathematics educators such as Jonathan and Randy is not likely to rapidly grow. (Roulet, 1998, p. 238)

Administrative support to facilitate finding time for teachers to work together seems essential. In Gwen and Julia’s case, administrative support through a compatible reporting system for grade nine was useful. Miriam also mentioned a supportive principal who found creative ways to build time for teachers into the schedule of the day.

Even if teachers are convinced of the benefits of using more innovative methods to evaluate their students, they are unlikely to succeed unless their supervisors, students, parents - and even their fellow teachers - understand and support their break with tradition. (Webb & Coxford, 1993, p. 13)

Teachers need time to develop and find resources that are samples of good instructional and assessment practices, and to organize and analyze samples of student work.
Administrative support is also required to educate parents and students as to new methods of assessment and reporting thus increasing validity and accountability. Parents and students are very oriented towards percentage grades, especially in the senior levels. There is a great deal of faith in that tradition.

... The most formidable impediment to innovative assessment techniques may be tradition. Educational assessment procedures that have been in place for decades are difficult to change. Tests and letter grades are well established as methods for evaluating and reporting students' achievements in mathematics. Because Americans have been fascinated ever since the end of the eighteenth century with measuring and numerically describing all types of national trends; it is no surprise that the society as a whole seems fixated on the importance of numeric evidence of student progress. Even if teachers are convinced of the benefits of using more innovative methods to evaluate their students, they are unlikely to succeed unless their supervisors, students, parents and even their fellow teachers understand and support their break with tradition. (Webb & Coxford, 1993, p.13)

Parents, teachers and students need more information about authentic assessment techniques if these techniques are going to be credible. The creation of sample activities, sample assessments, and exemplars of different levels of work would be helpful.

6.2 Where do we go from here?

In this study I have examined the practice of teachers who have chosen to use authentic assessment in their classroom. These are dedicated professionals who have chosen to grapple with issues of implementing new assessment techniques. Thus, some would argue whether educators can learn anything that would be applicable to teachers who may be mandated to implement authentic assessment techniques. What
can be said of teachers who may be mandated to employ authentic assessment in their classrooms and do not "believe" as Luke suggests is necessary?

I think that the first key message may not be as relevant to teachers who are being mandated to change their assessment practices. That is, teachers who are new to implementing alternative assessment techniques may not be faced with the dilemma of the contrast between a "content-driven" curriculum and a "problems-based" curriculum. As a starting point, teachers for whom the use of authentic assessment is imposed or new, may be most comfortable with a course of study that maintains a traditional style, and gradually introduces relevant problem solving activities. This parallels the current practice of the participants. The difference is that at this point, after the participants have developed expertise in authentic assessment activities, they can readily envision the need for a different type of curriculum.

However, the second key message, the need for a collaborative work culture seems especially valid as teachers begin to implement change that makes them uneasy. As well, issues of increasing expertise, maintaining consistency, sharing resources, and mutual support will be best addressed through a coordinated effort. Nonetheless, the willingness to make it work and the belief that this is the best way to teach mathematics may not be there and this could be an important area for administrators and those responsible for mathematics education to pay attention to and develop. Administrative support must be in place to give teachers time to learn new techniques and to share their knowledge, resources, frustrations, and successes.
My study specifically addressed teachers who were "on board" with reform in mathematics education, who were naturally moving to a problems-based curriculum, and who were experimenting on their own with authentic assessment strategies. Their attempts also have lessons to teach and could inform mathematics educators on how to prepare teachers for upcoming large scale assessments such as the planned Education Quality and Accountability Office performance assessment "testing" of grade nine mathematics students in Ontario and the general encouragement of developing a wide variety of assessment techniques. With the onset of mandatory, standard, performance based assessments such as EQAO (Education Quality and Accountability Office [Province of Ontario]) testing of grade nine students in mathematics, and the use of levels of achievement for assessment as part of current Secondary School Reform in Ontario, secondary school mathematics teachers will need to become familiar with new assessment techniques. There will be a wide variety of implementation models employed as well as a wide variety of reactions. Research questions that arise and require further research include: How are the experiences of teachers who adopt authentic assessment techniques because it is externally imposed different from the experiences of front-runners? Are the resources and support needed by the front-runners of authentic assessment also helpful to all mathematics teachers? What more do they need? How strongly does a teacher's view of mathematics influence their view of instruction and assessment? Will teachers now be changing their assessment practices to "teach to the test", even though it is performance-based, in the same way that some claim the curriculum was driven by
the exam? How do teachers adapt to change? Will changes in assessment dictate changes in instruction?

Another area that has not been addressed in this study and requires further research is the public perception of authentic assessment. This could specifically include student and parent perceptions. As students approach university age, marks are very important to them. What methods could be used to increase the validity of authentic assessment so that students and parents are more comfortable with incorporating authentic assessment in the evaluation of students? Also, some colleges and universities are including portfolios, essays, interviews, and projects as part of their admission process. This has implications and encourages the use of similar techniques in secondary school.

As authentic assessment moves out of the area of being an anomaly, practiced by a few secondary school mathematics teachers, to being mandated as part of general practice, many questions still remain and more will emerge. This study serves as a starting point.

6.3 Reflections on my Research

In this section I will first discuss some personal reflections on my research and then move into a broader context through a discussion of the limitations of my study and what I might have done differently. I will then discuss the areas of the research that I think went well. I will conclude with my reflections on the concept of authentic assessment itself.
It is difficult to engage in this type of study with my colleagues without it having a personal impact on my own practice. I would first like to discuss this impact. Towards the end of this study, I was given the opportunity to be one of the authors of the Provincial Course Profiles in Grade Nine Mathematics. Our task as writers was to take the course expectations from a curriculum policy document and scope out a sample course of study, including units, specific activities, and assessment and teaching strategies. As I began this task, the dilemmas and issues of my participants stood before me. I recalled their frustrations of attempting to teach two different paradigms, that of the traditional drill of mathematics skills and algorithms, and that of mathematics embedded in a rich problem solving context. My vision for the new curriculum profile was to offer something to my participants as well as to other teachers who were struggling with similar dilemmas. Luckily, the other authors of the course profiles felt similarly. Our vision was to “push the envelope” and to provide teachers with mathematics in a problem solving context. We were well aware that this might be challenging for many mathematics teachers, however, we also knew that there were already many available courses of study to satisfy the needs of the teachers who were uncomfortable with our vision. As I wrote, I imagined Julia’s musings,

I think the hardest thing about all of this is that I feel that I just want to start from scratch and change everything. I mean change. Well, every year I want to completely change the way I teach grade 9. I want to do the whole thing entirely differently - not just injecting an interesting activity into every unit. I want to start from scratch, sit down with somebody and completely change the way we teach grade 9. I sort of picture what I would do. I want to do many more activities, much more discovery, and much more group problem solving. I would love to do more projects since students can be learning different skills as they work
through the project. It doesn't need to be so much a topic by topic approach. This means revamping the entire way we teach the course.

(Julia, Interview transcript, January 14, 1999)

In writing the Course Profiles, I envisioned an activity based program in which mathematical skills were drawn out and practiced within a context. I am not sure that I would have realized that teachers were ready for this approach without hearing it from my participants.

I have also become more aware of the necessity to build a collaborative work environment and have been attempting to provide both time and space for my department members to naturally share ideas. Mathematics teachers are presently at the brink of implementing major curriculum changes and I am working to establish regular meetings of teachers to plan classroom activities, and to reflect on the implementation of those activities. As a Department Head, I also feel accountable for the assessment of students in Mathematics and need to justify the methods that teachers are using. I am working on developing teachers' skills in assessment methods through group efforts to establish assessment criteria, and to share, study, and discuss student responses, thus increasing consistency.

I now would like to turn to the limitations encountered in this study. It is easy to become frustrated researching five teachers at four different schools, while also being a full-time teacher myself. Due to the busy schedule of teachers it was not often possible to have a follow-up interview immediately after a classroom observation. Also, ideally I would have liked to have been a fly on the wall in each of the five participants' classes at all times since although I observed authentic assessment
activities, often the student and teacher feedback about the activity would take place in subsequent classes. I was thankful that the participants kept assessment log books because often when something regarding assessment occurred spontaneously, the participant recorded it and it served as a starting point in the next interview. I am not sure that these instances would have come forth without the record in the log book.

Ideally, it would have been beneficial to have all five participants in the same school. It would have made my research more manageable, since I spent quite a bit of time driving from school to school within a very large school board. It also would have helped the participants share resources and compare assessment practices. However, that was not possible since secondary school mathematics teachers who are using authentic assessment are currently somewhat unique. I found that the two focus group interviews helped to connect the participants and I was surprised at the power of those meetings. They served as a lively dialogue between participants which gave me rich data, and also gave the participants a forum for support. In hindsight, I probably could have included one other focus group meeting.

I was very appreciative of the efforts of my participants. They were very willing to give up their time for interviews, easily made accommodations to their classroom schedule to allow for observations, readily kept an assessment log book, and attended all sessions of the focus group. My journal comments mention that "As a researcher, you take whatever time and resources the participants are willing to give. You are somewhat at their mercy to supply you with meaningful data. Each
approaches it in his or her own way.” Luckily, my participants were very willing and their cooperation supplied me with very rich data.

I maintain that authentic assessment is an important supplement to traditional testing practices in secondary school mathematics. Students develop an understanding of mathematical concepts through problem solving and subsequent communication of solution. They also take more ownership of learning about mathematics through greater engagement of investigations. Some would argue that students can engage in problem solving without teachers implementing authentic assessment practices, yet, teachers show students that they value the process of problem solving by assessing and evaluating it. Students recognize that teachers evaluate what they value.

My fear about the use of authentic assessment is that teachers will not have the time to do justice to the process. Teachers are the ones who ensure that authentic assessment is authentic and valid. The validity of the assessment rests in teachers’ observations, establishment of viable criteria, and amalgamation of the assessments to make a judgment on the student’s achievement. Teachers need time and resources to develop their expertise. They also need time to share materials, strategies, and exemplars as a means of increasing consistency. Even if teachers do develop their expertise in assessment, the value and fairness of authentic assessment needs to be conveyed to students and parents. Authentic assessment data provides parents and students with more information than a numeric mark. Authentic assessment data informs parents and students about a student’s growth and areas of strengths and
weaknesses. It facilitates students setting goals for improvement and becoming a partner in assessment and in their own learning.

This study thus serves as a starting point. It indicates several key messages that emerged from the experiences of the five secondary school mathematics teachers. If mathematics educators are serious about authentic assessment, then these messages need to be heard for the implementation of authentic assessment to be realized.
References


Appendix A: Invitation to Participate
Appendix A

Invitation to Participate in a Research Project

Dear

This letter is being written to formally invite you to be a participant in a research project that will lead to a dissertation in fulfillment of the requirements of the degree of Doctor of Education at the University of Toronto. The project will be conducted within the Curriculum, Teaching and Learning Department of the Ontario Institute for Studies in Education, University of Toronto by myself, Christine Suurtamm and supervised by Dr. B. Kilbourn. The title of the research project is “Beliefs, Practices and Concerns about Authentic Assessment: A Case Study of Secondary School Mathematics Teachers”.

Purpose of the Study

As we have previously discussed, the purpose of this study is to investigate the implementation of authentic assessment in secondary school mathematics classrooms so as to bring forth the beliefs, practices and concerns of teachers as they implement these techniques in their mathematics program.

Selection of Case Study Participants

I have chosen to invite you to participate in this research project because of your current involvement in the “Assessment Group” which is a group comprised of secondary school mathematics teachers who have joined together to share some of their experiences with authentic assessment in mathematics education. Your involvement in this group indicates that to some degree you have been implementing new assessment strategies and also that you desire to expand your expertise by sharing with and learning from others.

Methodology

I will be gathering data through individual interviews with each teacher involved, classroom observation as well as participant observation at regular meetings of the “Assessment Group” and/or gather participating members together as a Focus Group. Data will also be gathered through the submission of copies of assessment tools and teacher log book. The process will span an 8 month period from April 1998 to November 1998.

The interviews will consist of five parts. The pre-interview will be to give you information about the nature of the research and the kinds of things that we will be discussing in subsequent interviews. It is also a time for you to ask questions about the research project. I will be making field notes at the end of the interview.
The second interview will be for approximately one hour and we will talk about the ideas you have about mathematics education, why you have chosen to implement alternate assessment techniques in your program, your experiences with these techniques as well as any concerns you have surrounding assessment in mathematics. It would also be interesting to learn of your goals concerning assessment. These interviews will be audio-taped so that all of the data will be captured and the awkwardness of note-taking will be eliminated. I will transcribe the tapes and thus be able to reread them and recall and reflect on our interviews.

Two classroom observations will occur with each participant at times that are convenient to the participant. The intent of this observation is to see the use of authentic assessment in action. Each observation will be followed by a 30 minute interview. The final interview will be towards the end of the project and we will discuss new experiences with authentic assessment, review previous issues, discuss new concerns, and review old concerns. Again, these interviews will be audio-taped.

During our focus group discussions, I will be taking short field notes and audio-taping the meetings so that I can recall the nature of the activities and discussion that has occurred.

Participants will also be asked to keep a record or log book of their experiences with authentic assessment over the 8 month period.

**Ethical Issues**

Confidentiality of our discussions is extremely important to me. The trust that you place in me will not be violated. The following steps will be taken to ensure that.

- Anonymity - All proper names and identifying details relating to the school, to teachers or to pupils will be altered in my notes, in interview transcripts and in the final thesis.
- Confidentiality - Field notes and interview transcripts remain confidential. They are not to be shared with others except the three members of my committee. Those members are only given the data with altered proper names and they also maintain the confidentiality of the material. The information of one participant is not shared with any other participants in the project.
- Protection against the possibility of evaluation - This study is not meant to evaluate teachers but to learn more about teachers' experiences of implementing authentic assessment. It is not possible to offer protection from a third party using the study in an evaluative way but ensuring anonymity and confidentiality is intended to protect individual participants.
- Right to Withdraw - You have the right to withdraw from this study at any time.

**Benefits of Participation**

I hope that by participating in this study you will have a chance to voice some of your experiences. I hope that I will give you an opportunity, a forum, for exploring your own understanding of assessment and sharing that with others.
Written Consent

If you are willing to participate in this research project, please sign the following:

I am willing to participate in the research project “Beliefs, Practices and Concerns about Authentic Assessment: A Case Study of Secondary School Mathematics Teachers”.

Signed ______________________________

Date ________________________________

I greatly appreciate your willingness to participate. Thank you.

Christine Suurtamm
Appendix B: Gwen's Authentic Assessment Activities
Appendix B-1

GRADE NINE PROGRAM

STUDENT: ___________________________  CORE GROUP: ___________________________

SUBJECT: MATHEMATICS  COURSE CODE: MAT IWO  TEACHER: ___________________________

<table>
<thead>
<tr>
<th>AREA OF EVALUATION</th>
<th>NOVEMBER</th>
<th>FEBRUARY</th>
<th>APRIL</th>
<th>JUNE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBJECT KNOWLEDGE/SKILLS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RESPONSIBILITY TO LEARNING


ATTITUDE and ABILITY

- cooperation as a team member | U M S V E E | U M S V E E | U M S V E E | U M S V E E |

OVERALL EVALUATION

- Unsatisfactory
- Marginal
- Satisfactory
- Very Good
- Excellent
- Not Evaluated

LEGEND:

U Unsatisfactory  Student is not currently meeting the requirements of the grade nine program and is therefore considered below level.
M Marginal  Student will need to make additional effort in order to ensure success as he/she is currently performing in the lower range of grade level expectations.
S Satisfactory  Achievement of this student coincides with grade-level expectations by the teacher.
V Very Good  Student is achieving in the upper range of teacher expectations for a grade nine student.
E Excellent  Student is achieving superior results, beyond grade expectations.
NE Not Evaluated

November comments: ___________________________

Teacher signature: ___________________________

Cumulative from September: ___________________________

# of absences  # of lateness

January comments: ___________________________

Teacher signature: ___________________________

Cumulative from September: ___________________________

# of absences  # of lateness

April comments: ___________________________

Teacher signature: ___________________________
Appendix B-2

**SQUARE PATIO COMPANY**

Your group is going into business to sell kits to make square patios. The components for the patios are:

1. Tiles that are 1 square metre in size
2. Frames to lattice in the tiles
3. Corners to attach the frames together
4. Border stabilizers that are an outside additional frame (only around the perimeter)

You can sell the materials alone as a kit for the do-it-yourself version OR you may charge more for an installed patio. See the table for the pricing information.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Kit price</th>
<th>Installed price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border stabilizers</td>
<td>$1.00</td>
<td>$2.00</td>
</tr>
<tr>
<td>Tiles</td>
<td>2.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Corners</td>
<td>1.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Frames</td>
<td>3.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Create an advertisement which will inform potential customers about how many pieces of each component they need for square patios of various sizes and what the cost will be for the kit or for the installed patio. Be prepared to answer your potential customers' questions quickly and accurately. Follow these suggestions to help you get prepared.

1. Find the number of components need for patios of sides 1, 2, 3, ... n. Design a chart to show this information as part of your presentation
   Build or diagram a few models, such as a patio of side 1 and a patio of side 2 to help you visualize the problem.

2. Describe your method of thinking for the n\textsuperscript{th} term.

3. Find the cost of both the do-it-yourself kit and the installed patios for each size. Display these costs as part of your poster along with the name of your company.

4. Provide 2 examples of companies that would price jobs using this method.

5. During the month of May, your company is offering 25% off of the installed patio price. Use this information to make your brochure more appealing to the consumer.

6. Your brochure has been set up to meet the needs of people wanting square patios. Determine the following costs. (These should be on a separate piece of paper)
   a) a patio measuring 9 m \times 9 m
   b) a patio measuring 5 feet \times 5 feet (0.3 m = 1 ft)
   c) a patio in the diagram to the right (each square is 1 m\textsuperscript{2})

   (what differences in pricing will occur?)

adapted from the *Mathematics Teacher*, January 1996
Appendix B-3

<table>
<thead>
<tr>
<th>DURING TODAY'S ACTIVITIES, HOW HAVE YOU DEMONSTRATED THE FOLLOWING?</th>
<th>unsatisfactory</th>
<th>marginal</th>
<th>satisfactory</th>
<th>very good</th>
<th>excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>(below grade level)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO-OPERATION WITH THE MEMBERS OF YOUR GROUP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APPROPRIATE AND POSITIVE BEHAVIOUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INITIATIVE AND SELF-DIRECTION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(did you make an attempt to solve your own problems?)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CREATIVITY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIME MANAGEMENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMPLETION OF ASSIGNED TASKS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAS AN ORGANIZED APPROACH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(followed through the activity in a logical order)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Select one area in which you felt was well done and provide a statement to support your assessment.

Select an area in which you could improve and state one suggestion you could use in other activities.
Appendix B-4a

MAT 1WO
PORTFOLIO PROJECT

This project will be a way to capture your growth in math this year. You will have the opportunity to choose samples of your work throughout the year to put into your portfolio. Each sample will be accompanied by a reflection sheet.

Choose samples that relate to one or more of the following categories.

- A) Problem Solving Ability
- B) Determination to stick with a difficult task
- C) Your most valuable experience in math
- D) Why math is important to learn
- E) What math means to you
- F) Something that you are proud of

By the end of the year you must have at least one sample from each category. Each sample should have a completed Reflection Sheet attached to it.

The following timelines should be used for due dates:
- Wednesday, November 18 - 1 sample
- Wednesday, December 16 - 2 samples
- Wednesday, February 8 - 2 samples
- Wednesday, March 10 - 2 samples
- Wednesday, April 14 - 2 samples
- Wednesday, May 12 - 2 samples
- June 14, 16, 18 - portfolio presentations/conferences

Criteria for Evaluation of your Portfolio Project:
- Completeness
- Quality of Self-Reflection

Personal Tracking (check off each category as it is submitted)

A ____  B ____  C ____  D ____  E ____  F ____
Appendix B-4b

**Portfolio Project Reflection Sheet**

Each reflective piece should include:

1. Name:___________  Date of Work:___________
2. A full page written response to the appropriate statements/questions

**PROBLEM SOLVING ABILITY**

♦ Select one of the problems that you have worked on and describe, in words, the steps you went through in coming up with your solution?
♦ How would you rate your ability to approach and solve problems?
♦ What does this sample of work show about your problem solving ability?

**DETERMINATION**

♦ Comment about your determination to stick with a difficult task.
♦ How does this sample of work reflect your determination?

**MOST VALUABLE EXPERIENCE IN MATH**

♦ Briefly describe this experience
♦ I think that this is a valuable experience in math because...
♦ How do you think that this experience will help you in the future?

**WHY MATH IS IMPORTANT TO LEARN**

♦ Discuss why you feel that this activity/piece of work demonstrates why math is important to learn

**WHAT MATH MEANS TO ME**

♦ This is what math means to me:
♦ This is how this work demonstrates this to me:

**SOMETHING THAT YOU ARE PROUD OF**

♦ I am proud of this piece of work because ...
♦ Some other things that make me proud of myself are...
**Quality of Self-Reflection**

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>- sample submitted does not meet the area of evaluation</td>
<td>- sample relates to area of evaluation</td>
<td>- sample relates to area of evaluation</td>
<td>- sample relates to area of evaluation</td>
</tr>
<tr>
<td>- questions have not been answered</td>
<td>- answers questions, but unable to draw relationships of written self-reflection with the chosen sample</td>
<td>- easy to see how the chosen sample meets the category i.e. problem solving</td>
<td>- excellent presentation of portfolio to the audience</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- good connections made between the sample and the self-reflective written comments</td>
<td>- excellent written explanation/self-reflection</td>
</tr>
</tbody>
</table>
### Portfolio Project Assessment

<table>
<thead>
<tr>
<th>Date</th>
<th>Audience (peer, teacher, other)</th>
<th>Quality of Self-Reflection (Self → Audience)</th>
<th>Audience's Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov-18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec-16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb-8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar-10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr-14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JUNE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B-5a

MATH IS FOR KIDS

Assignment: to create a program which could be used by younger students to work on their addition skills.

Marking Scheme: Your final mark will be determined by how many levels you add on to your program as well as how well you have completed those levels. The levels are described below as well as the highest possible mark for completing each level. All programs must:

- use proper programming style
- be very user friendly (something kids will understand). That means you should include instructions, colour, formatting, etc.

Basic Program
Write a program which will generate 2 random numbers between 1 and 50 and ask the user to find their sum. Sample question: 12 + 35 = 
Check to see if the user answered it correctly and output an appropriate message.

Highest possible mark: 10/22

Level 1
Add a loop to this program so that it will ask the user 10 different problems.

Most extra marks: 2

Level 2
Add to Level 1 so that the user can choose how many questions they want to try.

Most extra marks: 2

Level 3
Add to Level 2 to that the program keeps track of how many questions they get right and outputs their score (mark) and average at the end. Give them a message appropriate to how well they did.

Most extra marks: 4

Level 4 (you can do this one even if you only completed the basic program)
Add to any level program so that the user can enter the range of numbers that they want to use in the questions. For example a younger student might want questions using only number from 1 to 10 whereas an older student might want questions with integers from -50 to +50.

Most extra marks: 4

Due date: _____________________________

We will be adding graphics to this program later in the term.
# Math is For Kids

**Name:**

<table>
<thead>
<tr>
<th><strong>Basic Program</strong></th>
<th><strong>Level 1</strong></th>
<th><strong>Level 2</strong></th>
<th><strong>Level 3</strong></th>
<th><strong>Level 4</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>-generates 2 random numbers</td>
<td>-same as the basic program</td>
<td>-asks the user how many question they would like to try</td>
<td>-keeps track of the number of correct answers</td>
<td>-allows you to enter the range of random numbers</td>
</tr>
<tr>
<td>-asks you for the answer</td>
<td>-generates 10 different questions</td>
<td>-outputs a message for each answer</td>
<td>-outputs your score</td>
<td>-outputs a message after each question</td>
</tr>
<tr>
<td>-checks the answer</td>
<td>-outputs a message each time</td>
<td>-outputs an average (i.e. 5 / 10 = 50%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-remembers to enter an incorrect and a correct answer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Level 1
- as you run through this program you are prompted to answer different questions

## Level 2
- includes instructions
- uses delay and cls when appropriate

## Level 3
- includes instructions to the user, colour, and formatting that add to the overall appearance of the game

## Level 4
- includes instructions, colour, formatting and extra effects that make the game “out of the ordinary”

Please add any constructive criticism to help the person improve their program. For example, you may not understand what the program is asking for and they may need to clarify one or more instructions. Also, make at least one positive comment on their game.
### BASIC CRITERIA

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>- minor additions</td>
<td>- meets most criteria</td>
<td>- meets all criteria</td>
<td>- meets all criteria</td>
</tr>
<tr>
<td>-</td>
<td>- made some additions</td>
<td>- graphics added in appropriate places</td>
<td>- graphics enhance the program where appropriate</td>
</tr>
<tr>
<td>- doesn't meet all criteria</td>
<td>but nothing too exciting</td>
<td>- has done more than the minimum</td>
<td>- extensive use of graphics</td>
</tr>
</tbody>
</table>

| NOT IMPRESSED | NOT BAD | PRETTY GOOD | WOW |

**Comments:**

Marked by __________________________
For this project you are required to come up with a program that features animation (motion of an object or objects).

The program can take the form of a comic, an advertisement, a "moving" logo, or any other format you choose. It can run completely on its own or it can use input from the user to determine the movement of the object(s). The entire program does not need to run for a long time. If it is running on its own, it should run for a minimum of 10-15 seconds.

In order to enhance your program be sure to include the following:

⇒ a variety of colours
⇒ a variety of graphics commands
⇒ the use of takepic and drawpic
⇒ the use of string functions (outputting a phrase or information input by the user)
⇒ the use of "getch" at some point in your program (optional)
⇒ the use of mousewhere

During execution, marks will be awarded for:

♦ creativity
♦ use of the entire screen
♦ degree of difficulty
♦ recognition of some objects
♦ overall impression
♦ (see mark sheet for the breakdown)

Remember that it is more important to get a simple program to work than to have a complicated program which does not work.

You should plan this project on paper before beginning to program it. This plan must be approved and be brought with you each period.
### ANIMATION EVALUATION

**DST 3A0**

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>mark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RECOGNITION FACTOR (0 - 5 MARKS)</strong></td>
<td>/5</td>
</tr>
<tr>
<td>recognizing the picture and what's happening</td>
<td></td>
</tr>
<tr>
<td><strong>ANIMATION (0 - 5 MARKS)</strong></td>
<td>/5</td>
</tr>
<tr>
<td>the degree to which animation is present</td>
<td></td>
</tr>
<tr>
<td>time during which there is animation</td>
<td></td>
</tr>
<tr>
<td><strong>CREATIVITY (0 - 5 MARKS)</strong></td>
<td>/5</td>
</tr>
<tr>
<td>the degree to which Turing graphics are used</td>
<td></td>
</tr>
<tr>
<td>the idea</td>
<td></td>
</tr>
<tr>
<td><strong>USE OF COLOUR (0 - 5 MARKS)</strong></td>
<td>/5</td>
</tr>
<tr>
<td>variety and appropriate colour</td>
<td></td>
</tr>
<tr>
<td><strong>USE OF SCREEN (0 - 5 MARKS)</strong></td>
<td>/5</td>
</tr>
<tr>
<td>area of the screen which is used for animation</td>
<td></td>
</tr>
<tr>
<td><strong>USE OF STRING &amp; MOUSEWHERE (0 - 5 MARKS)</strong></td>
<td>/5</td>
</tr>
<tr>
<td>the use of string functions to add variety to</td>
<td></td>
</tr>
<tr>
<td>the program</td>
<td></td>
</tr>
<tr>
<td><strong>OVERALL IMPRESSION (0 - 5 MARKS)</strong></td>
<td>/5</td>
</tr>
<tr>
<td>rating compared to other projects</td>
<td></td>
</tr>
</tbody>
</table>

**FINAL MARK**
Appendix C: Julia's Authentic Assessment Activities
This diagram represents a cassette recorder just as it is beginning to play a tape. The tape passes the "head" (labelled H) at a constant speed and the tape is wound from the left hand spool to the right hand spool.

At the beginning, the radius of the tape on the left hand spool is 2.5 cm. The tape lasts 45 minutes.

1) Sketch a graph to show how the length of the tape on the left hand spool changes with time.

Length of tape on left hand spool

Time (minutes)
II) Sketch a graph to show how the radius of the tape on the left hand spool changes with time.

iii) Describe and explain how the radius of the tape on the right-hand spool changes with time.
Appendix C - 1c

WHAT IS BEING ASSESSED?
- ability to work with a "poorly defined" problem similar to those in real life
- use of mathematical processes
- ability to define and formulate problem

WHAT I SHOULD SEE:
- you using mathematics to communicate through graphs, pictures, symbols, numerical examples, words, etc.
- you solving problems using a variety of mathematical "tools"
- you being thoughtful, persistent, flexible, self-directed, and confident
- working well together developing group problem-solving skills

<table>
<thead>
<tr>
<th>ANALYTIC SCORING SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding the problem</td>
</tr>
<tr>
<td>0: Complete misunderstanding of the problem</td>
</tr>
<tr>
<td>3: Misunderstanding or misinterpreting part of the</td>
</tr>
<tr>
<td>problem</td>
</tr>
<tr>
<td>6: Complete understanding of the problem</td>
</tr>
<tr>
<td>Planning a solution problem</td>
</tr>
<tr>
<td>0: No attempt or totally inappropriate plan</td>
</tr>
<tr>
<td>3: Partially correct plan based on part of the</td>
</tr>
<tr>
<td>being interpreted correctly</td>
</tr>
<tr>
<td>6: Plan that leads or could have led to a correct</td>
</tr>
<tr>
<td>solution if implemented properly</td>
</tr>
<tr>
<td>Getting/presenting an answer</td>
</tr>
<tr>
<td>0: No answer or wrong answer based on an inappropriate plan</td>
</tr>
<tr>
<td>1: Partial answer</td>
</tr>
<tr>
<td>2: Incorrect answer following an incorrect plan that</td>
</tr>
<tr>
<td>was followed through correctly</td>
</tr>
<tr>
<td>3: Correct, complete answers - minor errors only</td>
</tr>
</tbody>
</table>
A group of students arrive at a campground to spend a weekend outdoors. They check in at the park office and they are given 4 flag poles and a piece of rope 50 meters long.

They are told that they can set up camp wherever they would like but they can only use an area as large as they can mark out using the rope and flag poles.

One of the students (a Glenview Summer School student of course), suggests that they pitch their tent next to a river. They explain that this means that the string has to be used for only three sides of the boundary.

Now they need to decide how they want to set up the boundary.

i) Describe in words (as fully as possible) how the length of the boundary changes as the width increases through all possible values. (Consider both small and large values of the width)
iii) The campers are interested in finding out what the length and the width of the boundary should be to obtain the greatest possible area. Describe, in words, a method by which you could find this length and width.

iv) Use the method you have described above to find this length and width.
<table>
<thead>
<tr>
<th>PROCESS</th>
<th>COMMUNICATION</th>
<th>ANSWERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• understanding the problem</td>
<td>• graphs</td>
<td>• correctness of final answer</td>
</tr>
<tr>
<td>• appropriate / effective plan</td>
<td>• diagrams</td>
<td></td>
</tr>
<tr>
<td>• different approaches</td>
<td>• words</td>
<td></td>
</tr>
<tr>
<td>• use of mathematical tools</td>
<td>• mathematical symbols</td>
<td></td>
</tr>
</tbody>
</table>

0 to 6 marks

0 to 4 marks

0 to 4 marks
Your assignment will include the following:

1. The actual dimensions of your room (your rough sketch)

2. The scale ratio that you have chosen to work with in your drawing

3. Using your scale ratio, calculate the dimensions of the room and major furniture (i.e. bed, desk, etc.)

4. A drawing of your bedroom using the scale dimensions calculated in #3.

### CRITERIA FOR EVALUATION

<table>
<thead>
<tr>
<th>Level 1 (poor)</th>
<th>Level 2 (okay)</th>
<th>Level 3 (really good)</th>
<th>Level 4 (awesome)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the criteria established, state at which level your assignment would be and provide a rationale for your decision.
Appendix D: Dave's Authentic Assessment Activities
## Linear Programming Group Presentation

<table>
<thead>
<tr>
<th>Level</th>
<th>Mark Range</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent Comprehension of problem</td>
<td></td>
<td>No clue</td>
<td>Vague</td>
<td>Solid</td>
<td>Solid</td>
</tr>
<tr>
<td>Translation</td>
<td></td>
<td>None, or almost totally incorrect</td>
<td>Incomplete or partially incorrect</td>
<td>Correct and complete</td>
<td>Correct and complete. Variables match information</td>
</tr>
<tr>
<td>Graph</td>
<td></td>
<td>None or incorrect</td>
<td>Incomplete or partially incorrect</td>
<td>Correct and Complete</td>
<td>Correct and complete</td>
</tr>
<tr>
<td>Evaluation of objective function/Conclusions</td>
<td></td>
<td>None, or errors. No conclusion or incorrect conclusion</td>
<td>Some errors or missing vertices. Correct conclusion from stated information</td>
<td>Complete and correct. Correct conclusion from stated information</td>
<td>Complete and complete. Correct conclusion from stated information. Extends solution.</td>
</tr>
<tr>
<td>What If? Questions from class</td>
<td></td>
<td>Not addressed</td>
<td>Not addressed</td>
<td>Yes, occasionally</td>
<td>Yes, extensively</td>
</tr>
<tr>
<td>Explanation</td>
<td></td>
<td>Vague or none or incomplete</td>
<td>Generally OK, may be partially incomplete</td>
<td>Correct and complete</td>
<td>Correct and complete. Extends &quot;What If?&quot; questions.</td>
</tr>
</tbody>
</table>

---

*Appendix D-1*
<table>
<thead>
<tr>
<th>Level</th>
<th>Mark Range</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Manager</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplies sufficient information</td>
<td>no</td>
<td>some</td>
<td>yes</td>
<td>yes, wide variety, relevant</td>
</tr>
<tr>
<td>Seeks sufficient information</td>
<td>no</td>
<td>some</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Information supplied is correct and complete</td>
<td>no</td>
<td>some</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Computes GDS and TDS</td>
<td>no</td>
<td>yes, possibly incorrectly</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Draws correct conclusion</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Couple Applying for Mortgage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Realistic expectations</td>
<td>no</td>
<td>generally</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Asks appropriate questions</td>
<td>no</td>
<td>usually</td>
<td>yes</td>
<td>yes, relevant</td>
</tr>
<tr>
<td>Supplies sufficient information</td>
<td>no</td>
<td>usually</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Has identified house and appropriate background</td>
<td>no</td>
<td>some</td>
<td>yes</td>
<td>yes, thoughtful and planned</td>
</tr>
<tr>
<td>Provides additional information when asked</td>
<td>no</td>
<td>usually</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

Appendix D - 2
<table>
<thead>
<tr>
<th>Level</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mark Range</strong></td>
<td><strong>Below 50</strong></td>
<td><strong>50 to 60</strong></td>
<td><strong>70 to 80</strong></td>
<td><strong>90 to 100</strong></td>
</tr>
<tr>
<td>Group participation (15)</td>
<td>Little or none Usually not on task</td>
<td>Some Usually on task</td>
<td>Active contribution to group Almost always on task</td>
<td>Active contribution to group Always on task Leadership role in group</td>
</tr>
<tr>
<td>Section Problems (10)</td>
<td>Not done, or done incorrectly most of the time</td>
<td>Completes with good level of accuracy</td>
<td>Completes with high degree of accuracy and proficiency</td>
<td>Completes with excellent accuracy and proficiency Describes extensions</td>
</tr>
<tr>
<td>Review Problems (10)</td>
<td>Chooses wrong procedure or applies procedure incorrectly</td>
<td>Sometimes chooses correct procedure Usually applies procedure correctly</td>
<td>Usually chooses correct procedure Almost always applies procedure correctly</td>
<td>Always chooses correct procedure and applies procedure correctly Offers alternative methods or solutions</td>
</tr>
<tr>
<td>Presentation (20)</td>
<td>Demonstrates little knowledge of appropriate procedure Usually unable to respond to student questions Lack of organization</td>
<td>Demonstrates some knowledge of appropriate procedure Usually able to respond to student questions Some degree of organization evident</td>
<td>Demonstrates thorough knowledge of appropriate procedure Almost always able to respond to student questions with confidence High degree of organization evident</td>
<td>Demonstrates mastery of appropriate procedure Responds to student questions with confidence High degree of organization evident Presentation extends learning by offering alternative solutions or &quot;What If&quot; discussions</td>
</tr>
<tr>
<td>Test (80)</td>
<td>Sometimes chooses and applies correct procedure Solutions often written without correct form or missing steps</td>
<td>Usually chooses and applies correct procedure Solutions usually written using correct form and complete</td>
<td>Almost always chooses and applies correct procedure Solutions almost always written using correct form and complete</td>
<td>Always chooses and applies correct procedure Solutions always written using correct form and complete Extends solutions or poses &quot;What If&quot; questions</td>
</tr>
</tbody>
</table>

**EXPECTED PERFORMANCE**
Appendix E: Miriam’s Authentic Assessment Activities
The Mama Mia Sauce Company wishes to expand its product line by branching out into the frozen food market. Mama Mia herself has decided that the products her company can produce and ship most economically are three-cheese ravioli and manicotti. Both the ravioli and manicotti will be filled with parmesan and romano cheeses but in different amounts. Also since storage space is restricted at the production facility, only a limited supply of each cheese is available at any one time. Marketing research carried out by Mama Mia's son Lorenzo, suggests that while frozen ravioli is less profitable to produce, it is the more popular of the two products. Ravioli will yield a profit of $8 per batch while manicotti will yield $11 profit per batch. The table below shows the amount of each kind of cheese needed to make one batch of ravioli and manicotti along with the total supplies of each type of cheese available. All frozen goods produced will be sold (Mama Mia finds waste very distasteful).

<table>
<thead>
<tr>
<th>Cheese</th>
<th>Ravioli</th>
<th>Manicotti</th>
<th>Supply Available (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ricotta</td>
<td>7</td>
<td>8</td>
<td>960</td>
</tr>
<tr>
<td>Parmesan</td>
<td>6</td>
<td>4</td>
<td>700</td>
</tr>
<tr>
<td>Romano</td>
<td>1</td>
<td>6</td>
<td>480</td>
</tr>
</tbody>
</table>

As Mama Mia's production manager, decide how many batches of ravioli and manicotti should be produced and sold to ensure maximum profit. Showing all your work, support your decision mathematically however possible (charts, graphs, algebraic models, equations, etc.) (Courtesy of Frank B. Pullano: University of Virginia)

Due date: _____________________________
The Mama Mia Sauce Company wishes to expand its product line by branching out into the frozen food market. Mama Mia herself has decided that the products her company can produce and ship most economically are three-cheese ravioli and manicotti. Both the ravioli and manicotti will be filled with parmesan and romano cheeses but in different amounts. Also since storage space is restricted at the production facility, only a limited supply of each cheese is available at any one time. Marketing research carried out by Mama Mia's son Lorenzo, suggests that while frozen ravioli is less profitable to produce, it is the more popular of the two products. Ravioli will yield a profit of $8 per batch while manicotti will yield $11 profit per batch. The table below shows the amount of each kind of cheese needed to make one batch of ravioli and manicotti along with the total supplies of each type of cheese available. All frozen goods produced will be sold (Mama Mia finds waste very distasteful).

<table>
<thead>
<tr>
<th>Cheese</th>
<th>Cheese Needed and Supply Available (lb)</th>
<th>Supply Available</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ravioli</td>
<td>Manicotti</td>
</tr>
<tr>
<td>Ricotta</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Parmesan</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Romano</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

1. As Mama Mia's production manager, decide how many batches of ravioli and manicotti should be produced and sold to ensure maximum profit. Showing all your work, support your decision mathematically however possible (charts, graphs, algebraic models-equations- etc)
2. If Mama Mia uses the optimal solution, how much of each type of cheese will be leftover?
3. If the supply of ricotta were increased to 1100 lb, what effect would this have on the optimal solution and the amount of each cheese leftover?
4. At what supply of ricotta will the optimal solution result in the least amount of cheese leftover?

Due date: ________________________________
Appendix E - 2a

MAT 3A0: Performance Assessment

Procedure:

1. Class 1:
   - distribute handout
   - place students in groups of 4
   - outline procedure for assessment and evaluation
   - students, on entering next class are to sign out a graphing calculator, and with their group to start work immediately
   - students will have only one class to perform any experiments

2. Class 2:
   - on entering class, students are to sign out graphing calculator and join group and start work immediately
   - groups may share data

3. Class 3:
   - continue with other class work
   - allow last 10 - 15 minutes of class for groups to get together

4. Class 4:
   - oral presentations

Evaluation:

1. Teacher assessment of group work: co-operation, on task etc.
2. Teacher and Student Evaluation of Oral Presentations.

Materials:

Graphing Calculators
Meter Sticks
String
Measuring Tapes
Graph Paper
MAT 3A0: Performance Assessment

A friend, frustrated by the lack of police progress, has asked you to investigate a heinous crime in which he was a victim. He hopes that you, a private investigator, will be able to solve it. After interviewing many witnesses and reviewing the police file, you have managed to narrow the field down to three prime suspects:

1) Rotten Rounder: age 38, height 167.5 cm.
2) Fredelle Angel Krueger: age 29, height 152.5 cm.
3) Sean Penn Guinn: age 22, height 182.5 cm.

Due to lack of resources, both money and time, you need to concentrate your investigation on only one of the suspects, and don't want to have any contact with them in fear of making them suspicious. In the police file, there was a diagram of footprints left at the scene of the crime.

![Footprints Diagram]

You wonder if the footprints might be used to estimate the perpetrator's height.

Vaguely you recall that back in grade 10 Math you studied something about variation, and that if it was direct variation between two sets of data, the data would produce a straight line graph for which you could formulate an equation to predict values. You remember doing some type of experiment in what's her name's class that had to do with a person's height and the length of a person's tibia (knee to ankle). You search your house top to bottom, and finally in a dingy basement corner you find your old math book. And in the book is the following:

<table>
<thead>
<tr>
<th>Student's (male) Name</th>
<th>Length of Tibia (cm)</th>
<th>Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>43</td>
<td>180</td>
</tr>
<tr>
<td>B</td>
<td>42.8</td>
<td>182</td>
</tr>
<tr>
<td>C</td>
<td>35</td>
<td>162</td>
</tr>
<tr>
<td>D</td>
<td>30.2</td>
<td>150</td>
</tr>
<tr>
<td>E</td>
<td>32.3</td>
<td>157</td>
</tr>
<tr>
<td>F</td>
<td>29</td>
<td>148</td>
</tr>
<tr>
<td>G</td>
<td>43</td>
<td>184</td>
</tr>
<tr>
<td>H</td>
<td>40</td>
<td>174</td>
</tr>
<tr>
<td>I</td>
<td>38</td>
<td>172</td>
</tr>
</tbody>
</table>
There was a sketch of a straight line graph, and the following note on how to use a graphing calculator to graph sets of data, draw a line/curve of best fit, and generate an equation to model the situation.

<table>
<thead>
<tr>
<th>Wind Speed (mph)</th>
<th>Equivalent Air Temperature (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>33</td>
</tr>
<tr>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>25</td>
<td>7</td>
</tr>
<tr>
<td>30</td>
<td>5</td>
</tr>
</tbody>
</table>

**Graphing:** With a graphing calculator graph this data to investigate if any recognizable pattern is discernible.

1. a) STAT 4 (CLR LIST) 2ND L1 (means list 1, above "1"), (the comma is above 7") L2 ENTER
   - this will clear any lists already in the calculator
b) To enter data: STAT 1 (Edit)
   - cursor should be at top of list 1
   - you are now ready to enter the data listed under Wind Speed
c) 5 ENTER 10 ENTER ...
d) Use the arrow right key to move to L2 - second list. ENTER the Equivalent Air Temperatures.
e) 2ND QUIT
2. 2ND STAT PLOT ENTER
   a) Plot 1 will be highlighted and the cursor will be flashing on ON. ENTER. Arrow down.
   Under Type use arrow keys to highlight the 1st graph-points, arrow down. X List should say L1, and Y List should say L2 if not enter, arrow down. Mark-select or highlight box (1st one). 2ND QUIT
3. Set the domain and range. Use the WINDOW KEY: and enter a suitable domain and range such as the following:
   - Xmin=0
   - Xmax=40
   - Xscl=5
   - Ymin=0
   - Ymax=40
   - Yscl=5
   - Xres=1
   then 2ND QUIT
4. GRAPH

**Determining the equation to a line or curve of best fit.**

1. Do you recognize the shape of the graph as being typical of some kind of function? Let's say you think it is a straight line and you want to determine the equation.
   a) STAT arrow right until CALC highlighted, arrow down to #4 Lin Reg highlighted or enter 4.
   b) Lin Reg (ax+b) will appear on the screen. Enter L1, L2, then VARS arrow right highlighting Y-VARS. Enter 1. This will perform Linear Regression on List 1 and List 2 and store the linear equation in Y1. ENTER. Then press ENTER again.
   c) The screen will tell you that the linear equation y=-1.062857143x+34.26666667 is the best fit equation.
d) GRAPH.
2. **Correlation Coefficient:** To know how well your data fits the regression equation select CATALOG(2ND) arrow down to DiagnosticOn and ENTER. Repeat the regression. This time, as well as the values of your selected equation appearing on the screen so will $r^2 = \ldots$ and $r = \ldots$. This is a correlation coefficient and gives an indication of how close the model fits the data. The closer the absolute value of $r$ is to 1, the better the fit.

Your experiment had yielded the result that for males:

$$y = 2.450388951x + 76.92059586, \quad r^2 = 9900982579 \quad \text{and} \quad r = 0.9950368123$$

or that for males:

Height = 2.45 (the length of the tibia) + 76.92, all measurements in cm.

with a correlation coefficient of .995, a very high correlation coefficient.

Several questions immediately occur to you:
- is there some type of relationship between the length of a person's stride and their height?
- would there be a difference between female and male length of stride and height?
- or is there some type of relationship between length of stride and how long their legs are?, or maybe part of their legs, for instance the length of the tibia?
- would there be a difference in the stride length if the person is walking slowly, quickly, running, forward, backward?

**YOUR TASK:** TO DETERMINE ON WHICH SUSPECT YOU SHOULD CONCENTRATE YOUR INVESTIGATION.

It is highly likely that you will have to defend your choice before a criminal reparations board. Prepare an oral presentation to be given to the Board detailing:

1) any experiment(s) conducted and the procedure(s) followed
2) data collected
3) data analysis
4) any graph(s) or equation(s) models developed and how it was done
5) any short comings or flaws in your reasoning, work, any assumptions you made, and their possible effect(s) on your results

The presentation must be no longer than 5 minutes and should include any material(s) that you consider will make an effective presentation.
Appendix E - 2e

Group Evaluation
1 - rarely 2 - occasionally 3 - most of the time 4 - always

<table>
<thead>
<tr>
<th>Student Name</th>
<th>stays on task</th>
<th>asks relevant questions</th>
<th>responds to others' contributions</th>
<th>group works independently</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
GROUP MEMBER EVALUATION

Name: ____________________

This is a strictly private evaluation.

Rate each person on a scale of 0 to 6 (decimal fractions accepted).

Take your time ... make this an honest evaluation. Your tally here is what percent of the final case study mark you think you and your partners deserve.

<table>
<thead>
<tr>
<th>Leadership</th>
<th>Initiative</th>
<th>Co-operation</th>
<th>Time &amp; Effort</th>
<th>Responsibility</th>
<th>Quality of Work</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Explanation

1. Initiative took an active role in suggesting ideas and wasted no time in getting down to work on the task at hand.

2. Leadership took an active role in organizing efforts and leading activities.

3. Co-operation worked well as a group member, helped others, shared ideas, listened, encouraged group performance.

4. Responsibility accepted jobs given by the group, had tasks completed on time.

5. Time and Effort the degree to which the person put forth the necessary time and effort on a consistent basis to ensure that a quality case study was produced.

Quality a thorough understanding of ideas, a desire to polish the final product, intelligent and articulate presentation.
### Oral Presentation

<table>
<thead>
<tr>
<th>1 - Fair</th>
<th>2 - Average</th>
<th>3 - Good</th>
<th>4 - Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group</td>
<td>Group</td>
<td>Group</td>
</tr>
<tr>
<td>Members:</td>
<td>Group</td>
<td>Group</td>
<td>Group</td>
</tr>
<tr>
<td></td>
<td>Group</td>
<td>Group</td>
<td>Group</td>
</tr>
<tr>
<td>Organization and Preparation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of Aids: charts, models, samples, graphs etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of Topic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class response and Participation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remarks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix F: Luke’s Authentic Assessment Activities
In this investigation/project you will work in groups of three over the next ten days (1 period per day) to investigate shampoo. Then you will present your findings to the class (2 periods total).

In particular, you will examine:
* the brands of shampoos used by students at 
* the characteristics of these shampoos which appeal to the people who buy and use them (survey),
* the physical and chemical properties of popular shampoos (lab investigation),
* the marketing and manufacture of shampoos (Internet),
* and the relationship between what people say about their shampoo preferences and their actual preferences relative to other shampoos (analysis).

Criteria:
1. You must submit a timeline, to be posted on the wall in our classroom, which indicates what you will be doing on each of days 2 to 10 which follow.

2. You must conference with Mr. L during class time at least twice during this project. In addition to getting help and direction from Mr. L, you will be asked about your progress, the decisions that you have made, and any unresolved questions that you have. You will be marked during each of these conferences, both as a group and individually. You must book a time with Mr. L for this.

3. You must start your work by preparing a survey to determine the shampoos used by students at . The reasons why these brands of shampoos were selected, and the properties of these shampoos that they like and dislike. You must administer your survey to a minimum of 20 other students at 

As soon as you have gathered this information you must write a note to Mr. L., telling him what 4 shampoos were the most interesting in your survey so that he can arrange to get some for use in class.

4. There will be a lesson on graphing methods on day four (whole period). You must share equally the job of organizing and graphing your survey data. This is to be handed in by the beginning of class on day six.

5. Next, you will examine physical and chemical properties of 3 or 4 shampoos in the lab. As a minimum you will be expected to examine and report on the following: appearance, colour, viscosity (at room temperature), change in viscosity due to temperature, deatht, other ability, pH, and cost per use. You are encouraged to explore other properties as well.

6. You will also do an Internet search to find out more about shampoo. The purpose of this search is to find out about what features make them sell better and about the chemical and physical properties of shampoo. Other questions you might consider include: How are shampoos made? Are there different types of shampoos? How have shampoos changed over the years? Or, you may choose other questions of your own. If you choose your own questions, check with Mr. L. to be sure that it is appropriate. In all cases your Internet investigation must tie in with the findings from your own survey and lab investigation.

7. You will then prepare a formal lab report outlining the objectives of your lab investigation, your methods, and your lab results only. This is to be handed in at the beginning of day 9.

8. Finally, you will present your findings to the class on day 11 or 12. Each group will be given 10 minutes max. and each member of the group must perform some part of the presentation. Also, you must submit an extra copy of your presentation notes for Mr. L. to follow while you are doing your presentation to the class.

All groups must be ready on day 11. Any group who is asked to present on this day, but cannot will be penalized 10%.

Evaluation
You will be evaluated both as a group and on an individual basis throughout this project. As outlined above, there are specific pieces to hand in throughout the project, you will be marked on your presentation, you will be marked on your in-class performance and conferences with Mr. L, and you will be asked to reflect upon certain aspects of your work in your journal from time to time.

In the course of this investigation, all students in your group must demonstrate their ability to perform the following math skills by hand: a tally, a frequency table, a bar graph, a histogram, and a circle graph, as well as calculate mean, median, and mode for a set of data.

All students will also be expected to demonstrate their ability to determine the following science skills: calculate density, compare viscosity of liquids, calculate pH, show safe lab work procedure, and carry out lab work in an organized manner.

Finally, all students will be expected to: demonstrate their understanding of survey sampling, make inferences and convincing arguments based on their data, assess bias in data collection methods, explain choices made in constructing graphs (i.e. choice of scale and units on each axis of a bar graph), draw appropriate conclusions from data, determine when it may be unreasonable to draw conclusions from a set of data, synthesise information from a variety of sources (survey, lab investigation, Internet) to create a coherent report, and make a presentation to the class.
### Individual Presentation Skills

<table>
<thead>
<tr>
<th>Presenter name</th>
<th>Speaking voice</th>
<th>Language &amp; explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>weak / adequate / exceptional</td>
<td>hard to follow / adequate / easy to understand</td>
</tr>
<tr>
<td>2</td>
<td>weak / adequate / exceptional</td>
<td>hard to follow / adequate / easy to understand</td>
</tr>
<tr>
<td>3</td>
<td>weak / adequate / exceptional</td>
<td>hard to follow / adequate / easy to understand</td>
</tr>
<tr>
<td>4</td>
<td>weak / adequate / exceptional</td>
<td>hard to follow / adequate / easy to understand</td>
</tr>
</tbody>
</table>

### Content and Method of Presentation

- **Coverage of material:** weak / adequate / thorough
- **Logical structure and flow:** disjointed / adequate / excellent
- **Use of visuals:** used none / too few / right amount

**You could have tried using:**

- **Clarity of visuals:** difficult to follow / adequate / easily understood
- **Conclusions/Insights:** none or limited / some / comprehensive
- **Justification for conclusions:** none or limited / some / comprehensive
- **Comments/suggestions:**

---
Appendix F - 3

Personal Strategic Plan: Making your Plan

The following is a list of learning/study activities which are likely to be helpful in mathematics and which may be used as part of your personal strategic plan assignment. You will be expected to prepare study notes in preparation for each unit test, and choose and carry out one other activity from items #2-9 below which you have not done on a regular basis prior to this course. This is to be done on a regular basis for the remainder of the semester.

Item one is required of all students.

1) Preparation of a concise and detailed set of study notes for each unit or chapter of work covered, which includes all of the key concepts for that topic. It will be helpful to include a small number of example solutions from the homework.

One task from items two to nine is also required.

2) The keeping of a homework question log. Students will keep a separate notebook, or a separate section in their mathematics notebooks, in which they write down two or three questions which arise during the completion of the assigned homework, each day, on average. It will the student's responsibility to get these questions answered by asking other students, someone in Albert's Den, or a mathematics teacher, and to record the answers for these questions in the log as well.

3) A homework problem log. Students will keep a list of all of the items assigned in class which are a problem for them each day. As a follow-up, the student will be expected to do each of these problems again for extra practice, prior to writing the corresponding unit test in class.

4) A homework problem analysis. The student will analyze the homework assigned during each unit, prepare a detailed written list of the different types of problems that were assigned, write a brief written description of the key points to remember for each type, and provide an example solution for each of the more difficult types of problems.

5) Perform an error analysis of the homework questions which are problematic for the student in the course of completing the assigned homework on a nightly basis. The student will also prepare (a few lines in writing) and implement a plan to deal with the pattern of errors that he or she is making prior to each unit test.

6) Keep a learning journal in which new insights, problems, and understandings, are described in detail. Two entries of approximately 50-100 words each would be expected per week. (Handwritten, first draft form is acceptable provided that they are legible and readable.)
### MST8--Problem Solving Evaluation--October 20, 1998

<table>
<thead>
<tr>
<th>Process components</th>
<th>Process evaluation</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understanding/exploration of the problem situation.</td>
<td></td>
<td>5/5</td>
</tr>
<tr>
<td>2. Modeling of the problem/formulation of a solution strategy.</td>
<td></td>
<td>5/5</td>
</tr>
<tr>
<td>3. Transform/manipulate/application of the solution strategy.</td>
<td></td>
<td>5/5</td>
</tr>
<tr>
<td>4. Inference/conclusions--understanding of key concepts &amp; patterns. Supports conclusions.</td>
<td></td>
<td>5/5</td>
</tr>
<tr>
<td>5. Communication of solution process and solution--clarity &amp; thoroughness of explanation.</td>
<td></td>
<td>5/5</td>
</tr>
</tbody>
</table>

**Total** /25
Math 1120 Classwork and homework evaluation

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample of work assigned</th>
<th>Work not complete</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Overall Mark /15

EVALUATION CRITERIA

Mathematical Communication /5 (organization, form and process)
- labeling work with: date
  source references, and question numbers
- writing out original questions
- showing required steps / mathematical form
- organization of work
- date or page number on each sheet
- organization of notebook

WORK ASSIGNED (from above)

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Problem areas indicated with an X.

Responsibility for own learning /5 (quality and degree of participation)
- indicating that all answers have been checked
- completion of all parts of assigned tasks
- following-up on difficulties (fixing them)
- seeking help as needed

Work production /5 (effort and participation)
- needs to get more work done in class
- has not made up for missed class time
- needs to finish all of the assigned work
- needs to get more work done at home

*Denotes general comments which are not date specific.

Student's plan for improvement:

Student's signature

Has all math work together in a separate binder Y / N

Parent's signature
Appendix G: Editing Quotes from Transcripts
Sample of Editing Quotes from Transcripts

The following example will demonstrate the editing of quotes to facilitate readability yet maintain intent:

Original Quote from Transcript:

Gwen: I actually find the assessment helps with the higher level, because you don’t tend to teach the higher level thinking skills and, you know, you may provide ‘do the extra question in the textbook’ or ‘try this’ but it’s not, you’re not giving a lot of kids the opportunity to show you that they can exceed a lot of the expectations that are outlined in the standards, like getting that last level is very, unless you provide activities that allow them to get to that level, a lot of times, you can’t evaluate it, and a lot of people misinterpret that.

Edited Quote:

Gwen: I actually find that the assessment helps with the higher level [thinking], because you don’t tend to teach the higher level thinking skills. You may ask them to ‘do the extra question in the textbook’ or ‘try this’ but you’re not giving a lot of kids the opportunity to show you that they can exceed a lot of the expectations that are outlined in the standards [Ontario Provincial Standards for Mathematics]. Getting that last level is very difficult. Unless you provide activities that allow them to get to that level, a lot of times, you can’t evaluate it, and a lot of people misinterpret that.

(Interview Transcript, April 23, 1998, [p. 63 of dissertation])