



Mathematics portfolios, NCTM goals, and students' perceptions : a complex analysis
by Teri Lee Willard

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education in
Secondary Curriculum and Instruction
Montana State University
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Abstract:

The National Council of Teachers of Mathematics (NCTM) has recommended changes in mathematics curriculum, instruction, and assessment, with these three documents: Curriculum and Evaluation Standards for School Mathematics (1989), Professional Standards for Teaching Mathematics (1991), and Assessment Standards for School Mathematics (1995). Many mathematics educators advocate the use of portfolios as one possible assessment reform.

This study investigated mathematics portfolios from the perspective of high school students who created their own. In addition, the teacher's perspective was examined, as the teacher's role in the implementation of portfolios was significant to the final results. The research question was: What are high school mathematics students' perceptions about portfolios as a tool for assessment, that is, for demonstrating their progress in fulfilling mathematics goals? The goals are: (a) students learn to value mathematics, (b) students become confident in their mathematical ability, (c) students become mathematical problem solvers, (d) students learn to communicate mathematically, and (e) students learn to reason mathematically (NCTM, 1989).

The study was conducted during the first semester of the 1995-96 school year in a small, rural high school. The subjects were three twelfth grade students in a class using integrated, innovative mathematics curriculum featuring real-world applications and utilizing technology, group work, and investigation. Students were to select their own portfolio items specifically documenting their accomplishments relative to the five NCTM student goals. Qualitative methods of data collection and analysis were utilized. For data analysis, the researcher used the method of constant comparison.

Students' interpretations of some NCTM goals did not align with the intent of NCTM and also varied from student to student. As a result, grading the portfolios proved to be problematic for the teacher. However, the students reported thinking critically about the meanings of the goals. One semester may not have been an adequate time period for the students to completely develop their portfolios with respect to all five of the goals. More effective classroom communication may have helped the teacher in implementation of portfolios. However, the teacher employed varying strategies to facilitate portfolio implementation. It appeared that the real value of portfolios in this study was as an information source for the teacher and a learning tool for the students.

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MONTANA STATE UNIVERSITY
Bozeman, Montana

May 1996

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of a thesis submitted by

Teri Lee Willard

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

6-17-96
Date

William Hall
Co-chairperson, Graduate Committee

6-18-96
Date

Sandra Semis
Co-chairperson, Graduate Committee

Approved for the Major Department

6/18/96
Date

Duane Mellip
Head, Major Department

Approved for the College of Graduate Studies

6/22/96
Date

RL Brown
Graduate Dean

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Signature Teri Willard

Date May 16, 1996

I dedicate this dissertation to my sister, Julie Ann, who was not fortunate enough to have the time to fulfill her dreams. I also would like to dedicate this work to my mother, Phyllis Norman Shamley, who eagerly awaited the day that I would finish this degree.

ACKNOWLEDGMENTS

I would like to thank my committee members for assisting me in the writing of this dissertation, in particular, my two co-chairs, Dr. Linda Simonsen and Dr. William Hall. In addition I would like to thank Dr. Sharon Walen who supported this research project from its inception almost two years before this final paper was completed. She was always there to discuss issues on almost a daily basis as I formed and refined my ideas. I would also like to thank Dr. Maurice Burke for providing me with the opportunity to work for the SIMMS project as a writer and later in assessment.

This research is partly supported by the National Science Foundation under Cooperative Agreement No. OSR 9150055. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

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ABSTRACT

The National Council of Teachers of Mathematics (NCTM) has recommended changes in mathematics curriculum, instruction, and assessment, with these three documents: Curriculum and Evaluation Standards for School Mathematics (1989), Professional Standards for Teaching Mathematics (1991), and Assessment Standards for School Mathematics (1995). Many mathematics educators advocate the use of portfolios as one possible assessment reform.

This study investigated mathematics portfolios from the perspective of high school students who created their own. In addition, the teacher's perspective was examined, as the teacher's role in the implementation of portfolios was significant to the final results. The research question was: What are high school mathematics students' perceptions about portfolios as a tool for assessment, that is, for demonstrating their progress in fulfilling mathematics goals? The goals are: (a) students learn to value mathematics, (b) students become confident in their mathematical ability, (c) students become mathematical problem solvers, (d) students learn to communicate mathematically, and (e) students learn to reason mathematically (NCTM, 1989).

The study was conducted during the first semester of the 1995-96 school year in a small, rural high school. The subjects were three twelfth grade students in a class using integrated, innovative mathematics curriculum featuring real-world applications and utilizing technology, group work, and investigation. Students were to select their own portfolio items specifically documenting their accomplishments relative to the five NCTM student goals. Qualitative methods of data collection and analysis were utilized. For data analysis, the researcher used the method of constant comparison.

Students' interpretations of some NCTM goals did not align with the intent of NCTM and also varied from student to student. As a result, grading the portfolios proved to be problematic for the teacher. However, the students reported thinking critically about the meanings of the goals. One semester may not have been an adequate time period for the students to completely develop their portfolios with respect to all five of the goals. More effective classroom communication may have helped the teacher in implementation of portfolios. However, the teacher employed varying strategies to facilitate portfolio implementation. It appeared that the real value of portfolios in this study was as an information source for the teacher and a learning tool for the students.

CHAPTER 1 INTRODUCTION AND LITERATURE REVIEW

Introduction

Mathematics educators have been issued a challenge by the National Council of Teachers of Mathematics (NCTM). The challenge includes reforming mathematics curriculum, instruction, and assessment. Three documents, published sequentially since 1989, have provided fuel to keep the fire of reform spreading. The first document, the Curriculum and Evaluation Standards for School Mathematics (1989), often referred to as the Curriculum Standards, advocated reforms in curriculum that would address “new goals for students” (NCTM, 1989, p. 5). These goals were for students to (a) learn to value mathematics, (b) become confident in their ability to do mathematics, (c) become mathematical problem solvers, (d) learn to communicate mathematically, and (e) learn to reason mathematically. (NCTM, 1989, p. 5-6) The second document, the Professional Standards for Teaching Mathematics (1991), Teaching Standards, provided direction for reforming instruction. The third document, the Assessment Standards for School Mathematics (1995), Assessment Standards, offered guidance for assessment methods that would reflect the new goals for students. The Assessment Standards also supplied criteria for measuring assessment methods. These criteria, or standards, are:

1. Assessment should reflect the mathematics that all students need to know and be able to do.
2. Assessment should enhance mathematics learning.
3. Assessment should promote equity.
4. Assessment should be an open process.
5. Assessment should promote valid inferences about mathematics learning.

6. Assessment should be a coherent process. (1995, pp. 11-21)

The authors of the Assessment Standards indicated that these standards may be applied to "specific assessment activities or to an entire assessment system" (1995, p. 9).

In each document specific details, such as a list of topics to cover at each grade level, were not provided. The concluding section of the Curriculum Standards asserted, "This [omission of details] is deliberate; a coherent network of relationships exists among the identified topics, and multiple paths are available throughout this network," (p. 252). In addition, the Assessment Standards maintained "this document is not meant to be construed as a 'how to' document" (1995, p. 3). These three documents left the design of cohesive plans that would bring curriculum, instruction, and assessment into an alignment reflecting the visions of the NCTM reform to teachers, school districts, and state and local leaders. One task, then, was to find methods of assessment that would correspond with the new curriculum and fulfill the NCTM goals for reform.

One potential solution to the challenge of devising new mathematics assessment methods may be the portfolio. Historically, portfolios were utilized in the arts as collections of work contained in a "portfolio" that the artists carried to display their work. Portfolios have also been used in language arts and English to display student work or progress. Graves and Sunstein (1992), who have been experimenting with writing portfolios at the college level, made this comment, "Only in the last five years have educators latched on to the portfolio as an alternative to evaluating the literate work of students, principally in the area of writing" (p. 1). Besides demonstrating student growth, some educators have offered portfolios as an assessment method that serves well as an instructional method. Mitchell said, "The major virtue of portfolios is that they can be designed to function simultaneously as a teaching tool and as an assessment

medium" (1992, p. 105). Frazier and Paulson commented on their experiences with portfolios: "Instruction and assessment came together into a single activity" (1992, p. 64). To determine whether portfolios can meet the challenges of assessment reform, they must be implemented and examined in the mathematics classroom.

Mathematics educators have been implementing and experimenting with portfolios in classrooms (Milliken, 1992; Knight, 1992; Owings & Follo, 1992), in entire schools (Hearne & Schuman, 1992; Leitner & Trevisan, 1993), and in entire states (Koretz, Stecher, Klein, McCaffrey, & Deibert, 1992). In fact, an assessment resource book, written to accompany an innovative high school mathematics curriculum in Montana developed by the Systemic Initiative for Montana Mathematics and Science (SIMMS) Project, contained an entire section on mathematics portfolios. The resource book examined the experiences of mathematics teachers who have used portfolios stating that "Portfolios provide a multifaceted view of performance, an opportunity for student self-assessment, and a forum for communication" (Walen & Hirstein, 1995, p. 32). For the purposes of this study, a mathematics portfolio was more than just a folder containing all student work for a given time period. Instead, the mathematics portfolio was defined as a purposeful collection of student work, where part of that work was selected by the student, and the student justified, in writing, each selection for the portfolio. The portfolios were a display case for students to demonstrate their learning.

To determine the value of mathematics portfolios, they must be studied within the classroom environment. It is also necessary to focus upon the people who are most critical to the success or failure of new methods. In this case, two groups are involved: teachers and students. Some mathematics teachers have already voiced their opinions in educational publications about their experiences with portfolios. Knight declared, "Math portfolios are a wonderful way for students to celebrate their learning" (1992, p.

72). Another teacher claimed, "Portfolios are the backbone of my program" (Anonymous, Walen & Hirstein, 1995, p. 32). Teachers are stating their opinions, but little is known about the opinions of students who use portfolios. The students are the ones who must deal with this new assessment form in mathematics classrooms and they must be willing to participate in the reform movement if it is to be successful. Research has shown that students have the power to influence mathematics reform. Walen (1993) and Ivey (1994) discovered that students play a critical role in the success of changes implemented by teachers in the mathematics classroom. Thus, reforms, like using portfolios, also need to be examined through the eyes of students.

Statement of the Problem

The purpose of the study was to analyze portfolios from the perspective of high school students who compile them in order that mathematics teachers can be more successful in implementing this new assessment form. More specifically, the research question was: What are high school mathematics students' perceptions about portfolios as a tool for assessment, that is, for demonstrating their progress in fulfilling mathematics goals?

The portfolio employed in this study was previously defined, but several other definitions are now presented. Perception is defined as the sum total of ideas, thoughts, attitudes, and beliefs expressed by the student. The NCTM student goals are defined using the descriptions given in the Curriculum Standards (1989):

1. Learning to value mathematics. Students should have numerous and varied experiences related to the cultural, historical, and scientific evolution of mathematics so that they can appreciate the role of mathematics in the development of our contemporary society and explore relationships among mathematics and the disciplines it serves: the physical and life sciences, the social sciences, and the humanities. Throughout the history of mathematics, practical problems and theoretical pursuits have stimulated one another to such an extent that it is impossible to disentangle them. Even today, as theoretical

mathematics has burgeoned in its diversity and deepened in its complexity and abstraction, it has become more concrete and vital to our technologically oriented society. It is the intent of this goal—learning to value mathematics—to focus attention on the need for student awareness of the interaction between mathematics and the historical situations from which it has developed and the impact that interaction has on our culture and our lives. (NCTM, 1989, p. 6)

2. Becoming confident in one's own ability. As a result of studying mathematics, students need to view themselves as capable of using their growing mathematical power to make sense of new problem situations in the world around them. To some extent, everybody is a mathematician and does mathematics consciously. To shop at the market, to measure a strip of wallpaper, or to decorate a ceramic pot with a regular pattern is doing mathematics. School mathematics must endow all students with a realization that doing mathematics is a common human activity. Having numerous and varied experiences allows students to trust their own mathematical thinking. (NCTM, 1989, p. 6)

3. Becoming a mathematical problem solver. The development of each student's ability to solve problems is essential if he or she is to be a productive citizen. We strongly endorse the first recommendation of *An Agenda for Action* (National Council of Teachers of Mathematics 1980): "Problem solving must be the focus of school mathematics" (p. 2). To develop such abilities, students need to work on problems that may take hours, days, and even weeks to solve. Although some may be relatively simple exercises to be accomplished independently, others should involve small groups or an entire class working cooperatively. Some problems also should be open-ended with no right answer, and others need to be formulated. (NCTM, 1989, p. 6)

4. Learning to communicate mathematically. The development of a student's power to use mathematics involves learning the signs, symbols, and terms of mathematics. This is best accomplished in problem situations in which students have an opportunity to read, write, and discuss ideas in which the use of the language of mathematics becomes natural. As students communicate their ideas, they learn to clarify, refine, and consolidate their thinking. (NCTM, 1989, p. 6)

5. Learning to reason mathematically. Making conjectures, gathering evidence, and building an argument to support such notions are fundamental to doing mathematics. In fact, a demonstration of good reasoning should be rewarded even more than students' ability to find correct answers. (NCTM, 1989, p. 6)

Significance of the Study

A major reason for conducting this research was that many educators are advocating portfolios with little research to justify the use of this assessment tool. Resource books, textbooks, and articles by respected educators, for example, Alternative Assessment: Evaluating Student Performance in Elementary Mathematics (1993), Assessment Alternatives in Mathematics: An Overview of Assessment Techniques That Promote Learning (1989), Assessment in the Mathematics Classroom: 1993 Yearbook (1993), Middle Grade Mathematics: An Interactive Approach (1995), Hamm and Adams (1992), and Knight (1992), were found by the researcher that promoted utilizing portfolios in the classroom. It would not be unreasonable to say that "almost everyone" is calling for teachers to experiment with portfolios while research on their educational value is a "slim collection." The phrase "slim collection" was used by Herman and Winters in the title of a recent article for Educational Leadership: "Portfolio Research: A Slim Collection" (1994, p. 48). The article is a synthesis of research on portfolios with Herman and Winters discovering:

In fact, of 89 entries on portfolio assessment topics found in the literature over the past 10 years, only seven articles either report technical data or employ accepted research methods. Instead, most articles explain the rationale for portfolio assessment; present ideas and models for how portfolios should be constituted and used; or share details of how portfolios have been implemented in a particular class, school, district, or state. Relatively absent is attention to technical quality, to serious indicators of impact, or to rigorous testing of assumptions. (1994, p. 48)

Herman and Winters also ascertained that there were 46 portfolio projects being implemented in the early 1990s (listed in the CRESST Alternative Assessment in Practice Database, 1993), with only 13 reporting on the quality of rater agreement. It is

alarming that so many people are "jumping on the portfolio bandwagon" with little research to support portfolio use.

Portfolios, and other alternative assessments, have the potential to effect changes in education. However, Herman and Winters made a crucial point: "The quality of change and the efficacy of the new practices must be subjected to inquiry" (1994, p. 55). By conducting this study, the researcher hoped to break new ground in the areas of portfolios, assessment reform, and students' perceptions and provide the impetus for more research in these areas. In addition, the researcher hoped to validate some of the claims that have been made about portfolios. By analyzing portfolios through the eyes of the students who actually use them, the researcher hopes to provide teachers with valuable information about the benefits of portfolios as a tool for assessing fulfillment of the NCTM goals.

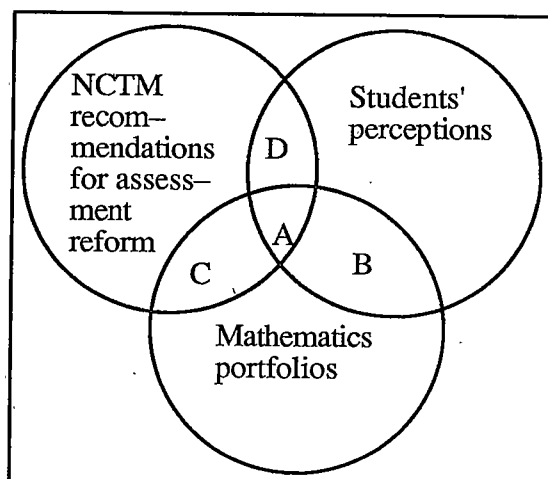
Review of the Literature

This research study had three components: the NCTM recommendations for assessment reform, the mathematics portfolio, and students' perceptions. Therefore, the literature review will have three parallel sections: (a) the NCTM component, (b) the portfolio component, and (c) a students' perceptions component.

Research studies involving these three components could be visualized in this diagram. Region "A" would contain studies of students' perceptions of mathematics portfolios as an assessment tool used in the spirit of the NCTM reform movement.

This research study lies in Region A.

Figure 1: Relationship of proposed study to the three components as viewed by the researcher.



Region C would represent studies investigating how the mathematics portfolio addresses the NCTM recommendations for assessment reform. Any research in this region will be presented in the Portfolio Component section of the literature review with related assessments included as well. Region D would be limited to studies of students' perceptions about the NCTM recommendations for assessment reform. The closest research applying to Region D will be discussed in the Students' Perceptions Component. In addition, research relevant to Region B, which would encompass studies of students' perceptions on portfolios and related assessments, will also be presented in the Students' Perceptions Component.

The literature review will begin with the NCTM Component. This section will examine the history of the NCTM mathematics reform movement and also analyze the relationship of this movement to reform in education in general. The section will end with a glimpse of the present state of assessment, in general, and mathematics assessment, in particular.

The NCTM Component

In this study, the NCTM goals for students provide the focal point for students' perceptions of portfolios. The researcher chose to utilize the NCTM student goals for two major reasons: (a) The NCTM has been a dominant force in the mathematics reform movement since 1989 and (b) the NCTM Curriculum Standards (1989) called for research.

The [Curriculum] Standards is based on a set of values, or philosophical positions, about mathematics for students and the way instruction should proceed. These values both are consistent with current research findings and establish a new research agenda. In the redesign of school mathematics, much careful research is needed. Instead of dealing solely with the study of what *is* happening in the teaching and assessment of mathematics instruction, research should deal more with what *ought to be*. (NCTM, 1989, p. 254).

Portfolios may or may not be a useful tool for instruction and assessment in the eyes of students, but students' insights provide valuable information for mathematics educators.

History of Reform. "If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might have viewed it as an act of war" (NCE, 1983, p. 5). The preceding strong statement appeared in A Nation At Risk, released in 1983, and provided the impetus for change in mathematics education, as well as other disciplines. Mitchell declared, "In 1983, a report that fixed public attention on the schools was published, and it took a national perspective. With A Nation At Risk, issued by the National Commission on Excellence, the inadequacies of American education were publicly acknowledged" (1992, p. 174-75). A Nation At Risk was also cited by the NCTM as one catalyst that drove them to publish the Curriculum Standards mentioned earlier. (NCTM, 1989, p.

1) The Curriculum Standards was the first of three NCTM documents and it called for reform in curriculum and evaluation. The second document called for reform in instruction and the third provided additional guidance in assessment.

In 1986, the (NCTM) Board of Directors created the Commission on Standards for School Mathematics to perform two tasks:

1. Create a coherent vision of what it means to be mathematically literate both in a world that relies on calculators and computers to carry out mathematical procedures and in a world where mathematics is rapidly growing and is extensively being applied in diverse fields.
2. Create a set of standards to guide the revision of the school mathematics curriculum and its associated evaluation toward this vision. (NCTM, 1989, p. 1).

The Commission accomplished these tasks by writing the Curriculum and Evaluation Standards for School Mathematics, released in 1989, after three years of work by four Working Groups consisting of classroom teachers, supervisors of mathematics education, educational researchers, teacher educators, and university mathematicians. The document contained fifty-four standards. Standards were defined as, "statement[s] that can be used to judge the quality of a mathematics curriculum or methods of evaluation" (p. 2). These standards were divided into four sections, one each for K-4, 5-8, 9-12, with the remaining section devoted to evaluation.

In the Curriculum Standards, the NCTM had formally called for the reform of mathematics education K-12, giving two major reasons for the reform movement. First, the organization perceived that teachers, students, and the public needed standards for mathematics education to safeguard quality, to provide goals, and to aid in change. Second, the world had changed and the country had "experienced a shift from an industrial to an information society" (NCTM, 1989, p. 3). This shift had caused "new social goals for education [that] include (1) mathematically literate workers, (2) lifelong learning, (3) opportunity for all, and (4) an informed electorate"

(NCTM, 1989, p. 3). These new goals for education caused the NCTM to specify these new student goals: “(1) that they [the students] 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). The authors of the Curriculum Standards contended that if appropriate experiences were provided for students then “they [the students] will gain *mathematical power*” (p. 5).

In the concluding section of the Curriculum Standards, the authors foreshadowed the importance of carrying the reform movement to all areas of mathematics education. They pointed to the need for guidance in reforming instruction by suggesting changes in teacher in-service and teacher education programs. Therefore, in 1989, the Commission on Professional Teaching Standards was established by the Board of Directors to produce a follow-up document to the Standards. This document, the Professional Standards for Teaching Mathematics, (Teaching Standards) would contain “standards that promote[d] a vision of mathematics teaching, evaluating mathematics teaching, the professional development of mathematics teachers, and responsibilities for professional development and support” (NCTM, 1991, p. vii). Therefore, the Curriculum Standards had been a main source of guidance for curriculum, but the Teaching Standards would guide teachers in developing new instructional strategies and be a guide for preparing in-service and pre-service teachers to meet the goals of the NCTM Curriculum Standards. However, teachers still needed guidance in tasks that would provide the correct interface between instruction and assessment.

In addition to foreshadowing changes needed in instruction, the final section of the Curriculum Standards identified the seriousness of not developing and/or using new assessment tools: “Without changes in how mathematics is assessed, the vision of the

mathematics curriculum described in the standards will not be implemented in classrooms, regardless of how texts or local curricula change" (NCTM, 1989, p. 252). Some initial guidance in this area was provided in the 1989 Curriculum Standards under the heading "Multiple Sources of Information":

Decisions concerning students' learning should be made on the basis of a convergence of information obtained from a variety of sources. These sources should encompass tasks that—

- demand different kinds of mathematical thinking;
- present the same mathematical concept or procedure in different contexts, formats, and problem situations. (NCTM, 1989, p. 196)

Furthermore, the authors of the Curriculum Standards promoted assessment as "an integral element of instruction" and stated a need for more than one type of assessment. Some suggestions for new assessments were "written and oral tests, observations, essays, and performance evaluations" (NCTM, 1989, p. 196).

As the reform movement gained momentum, the NCTM realized the need for more guidance in the important area of assessment. By 1992, the NCTM had appointed three working groups and a management team to compose new assessment standards based on, and intended to complement, the Curriculum Standards. The Assessment Standards for School Mathematics: Working Draft, (Working Draft), was released in October of 1993. The working groups relied not only on the 1989 Curriculum Standards, but also on important information from other sources, one of the most important being the authors' own experiences as writers of earlier documents, researchers, developers of new assessment methods, participants in innovative projects, and as classroom teachers. (NCTM, 1995) The authors of the Working Draft revised the document with comments from over two thousand reviewers and released the formal document, the Assessment Standards for School Mathematics (Assessment Standards), in May of 1995. In the Assessment Standards assessment is defined as

“the process of gathering evidence about a student’s knowledge of, ability to use, and disposition toward, mathematics and of making inferences from that evidence for a variety of purposes” (1995, p. 3). The authors pointed out that “In order to develop mathematical power in all students, assessment needs to support the continued mathematics learning of each student” (1995, p. 6) and that “Assessment occurs at the intersection of important mathematics content, teaching practices, and student learning” (1995, p. 6). Moreover, the Assessment Standards noted the communication aspect of assessment:

Assessment is a communication process in which assessors – whether students themselves, teachers, or others – learn something about what students know and can do and in which students learn something about what assessors value. . . . When instruction pursues one set of goals and the assessment . . . pursues another, students are faced with a dilemma and must assume that the goals of assessment are the ones that count. (1995, p. 13)

Now, the challenge is for mathematics educators to develop new assessment tools that foster learning and communication between the assessors and those who are assessed.

Forward looking mathematics educators had already begun development of new assessments even before the publication of the three NCTM documents. For example, a 1989 handbook released by the Assessment Committee of the California Mathematics Council Campaign for Mathematics (Stenmark, 1989), suggested assessment alternatives such as portfolios, student projects, journals, open-ended questions, videotapes, audio tapes, computer demonstrations, dramatic performances, bulletin boards, debates, student inventions, reports, simulations, mathematical art, and construction of physical models. As changes in mathematics education and assessment were being proposed, changes were underway in other disciplines as well. “As we enter the 1990s, we are experiencing fundamental changes in the way we view and conduct assessment in American schools,” stated Stiggins (1991, p. 263). Educators in other disciplines began to design and experiment with alternative forms of

assessment, as well. Entire issues of educational journals were devoted to assessment issues, for example, Educational Researcher (Dec., 1989), Educational Leadership (April, 1989), Educational Leadership (May, 1992) and The Middle School Journal (Nov., 1993), not to mention the hundreds of individual articles permeating educational journals. The use of a variety of assessment forms was advocated by educational authorities, for example, Paulson, Paulson, and Meyer (1991), Hamm and Adams (1992), and Graves and Sunstein (1992), and by teachers who reported their experiences using new assessments in journal articles, such as, Slater (1994), Milliken (1992), and Chiseri-Strater (1992). During the early 1990s, then, definitions of "new" assessment forms abounded in educational literature, one example being the term "alternative assessment." The authors of Alternative Assessment commented:

The phrase "alternative assessment" is becoming increasingly popular, and it is tempting to ask, "Alternative to what?" In the most basic terms, it is an alternative to the traditional assessment that has dominated American education for most of this century. . . . Within classroom assessment, teachers' old tools (i. e., drill sheets, true-false tests, matching tests) were designed to assess students' knowledge of facts and procedures . . . [and were not effective] in measuring or fostering students' "higher-order" skills of thinking, solving problems, communicating, and collaborating. In the case of external assessment, traditional multiple-choice standardized tests have also been found to be lacking if one wishes to measure these same "higher-order" skills. (Statewide Systemic Initiative Technical Assistance Project, 1993, p. 1)

"Alternative assessment" has been on the minds of educators in such disciplines as science (Slater, 1994; Shavelson & Baxter, 1992), language arts (Lewis & Lindaman, 1989; Graves & Sunstein, 1992; Belanoff & Dickson, 1991), and social studies (Aschbacher, 1992).

In addition to alternative assessments, other types of assessment were being defined and experimented with by teachers in mathematics and other disciplines. New terms were "authentic assessments" and "performance assessments." Meyer gave these

definitions in an article titled "What's the Difference Between Authentic and Performance Assessment":

In a performance assessment, the student completes or demonstrates the same behavior that the assessor desires to measure. There is a minimal degree, if any, of inference involved. . . . if the behavior to be measured is writing, the student writes. The student does not complete multiple-choice questions about sentences and paragraphs.

In an authentic assessment, the student not only completes or demonstrates the desired behavior, but also does it in a real-life context. "Real life" may be in terms of the student . . . or an adult expectation. . . . The significant criterion for the authenticity of a writing assessment might be that the locus of control rests with the student. (1992, p. 40)

It appears that interest in assessment has been rampant since at least 1989 in mathematics, as well as in other disciplines.

Present State of Assessment. With all the interest in new assessments, one might wonder what assessments are currently being used. Ruth Mitchell, in her book, Testing for Learning (1992), reported this fact about standardized testing, "The National Commission on Testing and Public Policy estimates in its 1990 report . . . that students take 127 million separate tests in a year. Since there are 41 million students in American public schools, that works out to an average of three tests each, but since it is an average some students must take many more than three" (p. 4). As late as 1990, then, schools were still relying heavily on standardized tests.

Despite the fact that students were still taking standardized tests on a regular basis in 1990, schools and teachers were also implementing alternative assessments as seen by research studies (Aschbacher, 1992; Borasi & Rose, 1989; Hearne & Schuman, 1992; Koretz et al., 1992; Kulm, 1993; Leitner & Trevisan, 1993; Lesnak, 1989; McMullen, 1993; Owings & Follo, 1992; Powell & Lopez, 1989) and informal teacher reports (Chiseri-Strater, 1992; Frazier & Paulson, 1992; Goerss, 1993;

Hansen, 1992; Katims, Nash, & Tocci, 1993; Knight, 1992; Milliken, 1992; Slater, 1994; Voss, 1992). But how widespread is the use of new assessments, particularly in mathematics? Garet and Mills (1995) reported that "Research on the effects that the Standards [Curriculum Standards] document has had on practice has been relatively sparse. The NCTM has begun a project to monitor the change process, although results have not yet been reported" (p. 380). Since the results were not yet in, Garet and Mills (1995) reported the results of their own 1991 smaller scale study that examined changes effected by the Curriculum Standards. Changes in four areas of instructional practice, including curriculum, teaching, technology, and assessment, were examined by mailing surveys to the mathematics department chairs of about 550 public secondary schools in Illinois, Indiana, Michigan, and Wisconsin. Questions related to practices in first-year algebra only for 1986 and 1991 and projected practices for 1996. About 72% of the surveys were returned providing the following results: (a) In curriculum, the emphasis of topics in first-year algebra had begun to shift towards those advocated by the Curriculum Standards, with more change expected by 1996. (b) In instruction, lecture, with discussion and in class problem sets, was still dominant in 1991, cooperative learning had increased substantially, but use of written and oral reports was very limited. (c) In technology, use of calculators had greatly increased from 1986 to 1991 and the use of computers was expected to increase likewise by 1996. (d) In assessment, short-answer tests had not declined in usage and were still the prevailing assessment type, use of multiple-choice tests was increasing slightly, and use of written and oral reports and group tests was sparse. Results of the study, then, showed that the changes advocated by the NCTM documents were occurring, but slowly, particularly in the areas of instruction and assessment. (Garet & Mills, 1995)

It is evident that mathematics education is in the midst of a reform movement initiated by the NCTM, but reform methods are by no means in place everywhere, as

indicated by the popularity of standardized tests as late as 1990 and by the practices of mathematics teachers, as reported by Garet and Mills (1995). One might wonder what would aid in the implementation of new instructional and assessment methods.

Harnisch and Mabry have this opinion: “‘Alternative assessment’ is perhaps the most active area in assessment policy today. It is an area in which focused research has the potential for substantially aiding decision makers and improving practice” (1993, p. 182). They made it clear that research would inform teachers about using new assessments. The research study to be reported here incorporates both the NCTM goals for students and an assessment form relatively new to mathematics, the portfolio. The role of the portfolio in this study will now be examined.

The Portfolio Component

As was noted earlier, this research study lies at the intersection of the NCTM recommendations for assessment reform, students’ perceptions, and portfolios, or portfolio-related assessment, in region A of Figure 1 (page 8). The role of the portfolio and its potential as an assessment tool fulfilling the NCTM recommendations (region C) will be examined in this section. The section will end with an overview of research studies of alternative assessments in mathematics, including portfolios.

The Role of the Portfolio. The portfolio in this study played two roles:

(a) It was a process that students experienced as they selected and justified items for the purpose of demonstrating their learning. (b) It was the product through which students displayed their learning. Since the portfolio played such a crucial role, it was well defined for the teacher participating in this study. The portfolios were not just folders containing all student work or folders of work selected by the teacher. The students were given the opportunity to select items for inclusion and were required to justify

those choices. Two types of portfolios were used by the students during this study. The first type was the portfolio guided by the teacher. The teacher supplied guidelines for item selection, but students had complete freedom in selecting items and were required to justify their selections in writing. The second type of portfolio was a special portfolio prepared by the student to reflect the NCTM student goals. This portfolio will be described in more detail in Chapter 2.

Since portfolios played such a major role in this study, the question must be asked whether a portfolio is even a worthwhile assessment tool. Webb (1992, p. 679) called for a theory of mathematics assessment so that new methods could be designed upon sound principles. He stated:

Designing or selecting assessment situations to meet a particular purpose can be a very complicated task. A theory should help simplify this process by explaining how a situation works as students respond to it and how the different aspects of assessment interact with one another. (p. 680)

He indicated that there are still many unanswered questions about mathematics assessment and that, although some research studies have been conducted, "there is very little mention of theory within these studies and no mention of a theory of mathematics assessment" (p. 680). If a theory existed, the researcher could apply this theory to the mathematics portfolio used in this study, but lacking a theory the researcher will apply the NCTM guidelines. The following discussion presents the potential that the portfolio used in the study had for fulfilling each assessment standard.

Portfolio as Assessment Tool. As was stated earlier, the NCTM had a vision of assessment. They used that vision to design criteria upon which assessments could be judged to determine whether those assessments fulfilled the vision of the Curriculum Standards (1989). These criteria are the six assessment standards proposed in the Assessment Standards (1995). As each standard is now presented, the question

will be asked: How does the type of portfolio used in this study measure up to the NCTM assessment standards?

“The Mathematics Standard: Assessment should reflect the mathematics that all students need to know and be able to do” (NCTM, 1995, p. 11). Suggestions for items to be included in a portfolio include projects, writing assignments, journal reflections, open-ended questions, and problem solving, where students have the opportunity to make connections and show what they are able to do. Students work on these types of tasks for a greater amount of time than is allowed on usual assessments like paper-and-pencil achievement or even teacher-made tests. The portfolios in this study contained a variety of items. Students were given the freedom to select items and the participating teacher controlled the curriculum. However, the type of portfolio used had the potential to demonstrate important mathematics as defined by the Curriculum Standards.

“The Learning Standard: Assessment should enhance mathematics learning (NCTM, 1995, p. 13). Authorities and teachers who have tried portfolios noted that they are teaching tools: “Early data that show their [portfolio’s] use as a medium for instruction is more than promising” (Graves, 1992, p. 1). “Portfolios become an intersection of instruction and assessment: they are not just instruction or just assessment but, rather, both. Together, instruction and assessment give more than either gives separately” (Paulson, Paulson, & Meyer, 1991, p. 61). This study looked at portfolios as an assessment tool through the eyes of students. Students were asked for their perceptions of whether portfolios could demonstrate their learning and, in asking for those perceptions, the researcher gained information on whether portfolios “enhanced” their learning. The students had the opportunity to draw the connection between the two uses, instruction and assessment.

"The Equity Standard: Assessment should promote equity" (NCTM, 1995, p. 15). Portfolios have been shown in at least one study to be more equitable in terms of gender and socioeconomic status. Hearne & Schuman (1992), in a study of an elementary school implementing portfolios in mathematics, found no differences between portfolio ratings given by teachers for boys versus girls or for low versus high socioeconomic students. They concluded that portfolio assessment may be a more fair method of student assessment in terms of gender and economic status. Looking at equity from the standpoint of learning styles, the portfolios used in this study addressed equity in at least two ways: (a) Portfolios allowed students more time in preparing the items. The portfolios were not like timed testing situations. (b) Portfolios allowed students to select items that reflected their areas of strength. In addition, this research showed how different types of students perceived using portfolios.

"The Openness Standard: Assessment should be an open process" (NCTM, 1995, p. 17). Teachers have reported using portfolios to show parents the accomplishments of their children and, in some cases, even having the children show the portfolios to the parents (Hebert, 1992; Goerss, 1993; Milliken, 1992). One teacher report was found where students shared their portfolios with other students (Knight, 1992). Portfolios can be shared with students, teachers, administrators, parents, and other interested parties. In addition, teachers can show exemplary portfolios and provide performance criteria for a portfolio. Therefore, a portfolio could fulfill the openness criteria for assessment practices.

"The Inferences Standard: Assessment should promote valid inferences about mathematics learning" (NCTM, 1995, p. 19). Informal reports have shown the richness of data on student's abilities and thoughts about mathematics that can be collected in portfolios. However, the authors of the Assessment Standards pointed out that, "New forms of assessment, such as portfolios and extended projects, may create

new sources of bias" (1995, p. 19). When students complete portfolios there is always the opportunity for outside assistance and some students may have access to more resources, such as computers or books, than other students. It is also pointed out that bias in scoring can result with more complex tasks such as portfolios. For the portfolios in this study, the teacher did all the scoring.

"The Coherence Standard: Assessment should be a coherent process" (NCTM, 1995, p. 21). The authors of the Assessment Standards define three parts of coherence.

First, the assessment process forms a coherent whole; the phases fit together. Second, the assessment matches the purpose for which it is being done. . . . Third, the assessment is aligned with the curriculum and with instruction. Students' learning connects with their assessment experiences. (1995, p. 21)

Portfolios certainly have the potential to be one phase of assessment, but work is needed to assure that portfolio assessment fits with other assessments, matches the purpose for which it is used, and aligns with the curriculum and instruction.

It has been seen that the portfolio used for this research study has the potential to address the six assessment criteria, but, of course, the way that schools, teachers, and students use portfolios will determine how well it fulfills those goals. Next, studies that addressed issues similar to those of the proposed study will be examined.

Overview of Relevant Portfolio – Related Research. As stated earlier, this study analyzed the use of portfolios as an assessment tool from the perspective of the student. Portfolios can contain many alternative assessments which may include, but not be limited to, journal writing (both summaries of mathematical topics and feelings about mathematics), reports on mathematical topics, interviews, attitude surveys, problem-solving activities, responses to open-ended questions, and self-evaluation or assessment surveys. Therefore, results of research on alternative

assessments will also be considered. A brief overview of findings about alternative assessments, including portfolios, journals, and writing in mathematics, will be presented.

Results have shown that alternative assessments are a catalyst for changing mathematics teachers' methods of instruction (McMullen, 1993; Telese, 1993; Kulm, 1993; Flexer & Gerstner, 1993; Leitner & Trevisan, 1993; Koretz et al., 1992; Aschbacher, 1992; Borasi & Rose, 1989). It is not clear from this information whether alternative assessments are becoming methods of instruction, but it is clear that they are influencing instruction in significant ways. In addition, mathematics teachers using alternative assessment strategies were found to have positive changes in attitude (Koretz et al., 1992; Aschbacher, 1992; Kulm, 1993). Students were also reported to have positive changes in attitude (Leitner & Trevisan, 1993; Borasi & Rose, 1989; Lesnak, 1989; Powell & Lopez, 1989; Kulm, 1993; Telese, 1993; Aschbacher, 1992; Koretz et al., 1992), although in three of these studies, student attitude was not measured directly, but was reported by teachers (Leitner & Trevisan, 1993; Aschbacher, 1992; Koretz et al., 1992). Three studies showed improved achievement using writing as instruction and assessment in mathematics (Borasi & Rose, 1989; Lesnak, 1989; Powell & Lopez, 1989). However, two of those studies relied on self-reports from the students not quantifiable achievement results. Researchers in four studies pointed out the power of self-reflection and critical thinking afforded students when alternative assessment strategies are employed (Owings, & Follo, 1992; Aschbacher, 1992; Borasi & Rose, 1989; Powell & Lopez, 1989). Two researchers noted that using alternative assessments changed the classroom atmosphere to a more open and non-threatening environment (Telese, 1993; Borasi & Rose, 1989). A study of the implementation of mathematics and writing portfolios in an elementary school compared achievement test scores to portfolio scores given by teachers. It was found that special education

students' portfolios scored low in comparison to average students and that gifted students' portfolios had the highest scores. The researchers concluded that portfolios are at least as good as standardized tests in portraying student ability. (Hearne & Schuman, 1992) One point stood out in the examination of the studies of alternative assessments, including writing and portfolios: In some studies, the researchers focused on the portfolio as a device for reporting scores and comparing students or schools (Koretz, et al., 1992; Hearne & Schuman, 1992), while in the rest of the studies the assessment was studied for its effect on teachers and/or students. However, even though the Koretz et al. (1992) study focused on using portfolios in comparing students, effects on teachers and students were also examined qualitatively.

The preceding brief summary of research on the use of alternative assessments in mathematics, including portfolios and writing, showed that the body of empirical research is small. On particular assessment types, such as portfolios, it is even smaller. The research study reported here lies in the affective domain, which McLeod defined as "a wide range of beliefs, feelings, and moods that are generally regarded as something different from pure cognition" (1989, p. 245). Research studies with an affective component and a portfolio assessment component are rare indeed as pointed out by Owings & Follo, "There is a paucity of empirical research on the affective contributions that portfolio assessment may have on students" (1992, p. 12).

Recall, that this study lies at the intersection of student affect, assessment method, and the NCTM recommendations for reform. Of twelve studies on alternative assessments reviewed, including writing in mathematics and portfolios, ten contained a component of student affect. However, only one study involved high school students, the subjects of this study (Telese, 1993). The summary table shows the grade level, the type of alternative assessment, the research design, and whether the study focused

on student affect or student achievement or on teacher affect or teacher instructional methods.

Table 1: Empirical research summary table.

RESEARCHERS	AA	PA	WA	QL	QN	E	H	CL	SAF	SAC	TAF	TIN
Aschbacher (1992)	X			X		X	X		X		X	X
Borasi & Rose (1989)			X	X				X	X	X	X	X
Flexner & Gerstner (1993)	X			X		X					X	X
Hearne & Schuman (1992)		X		X	X	X				X		
Koretz et al. (1992)		X		X	X	X			X	X	X	X
Kulm (1993)	X		X		X	X	X		X		X	X
Leitner & Trevisan (1993)		X		X		X			X	X	X	X
Lesnak (1989)			X	X	X			X	X	X		
McMullen (1993)	X		X		X	X	X		X		X	X
Owings & Follo (1992)		X		X		X			X	X		
Powell & Lopez (1989)			X	X				X	X	X		X
Telese (1993)	X		X		X	X	X		X			

KEY: AA – Alternative Assessment, PA – Portfolio Assessment (only method in the study), WA – Writing as Assessment, QL – Qualitative Study, QN – Quantitative Study, E – Elementary, CL – College, HS – High School, SAF – Student Affect, SAC – Student Achievement, TAF – Teacher Affect, TIN – Teacher Instruction

Of those ten studies, three relied on teacher report of student affect (Aschbacher, 1992; Koretz et al., 1992; Leitner & Gerstner, 1993). For that reason, those studies will not be considered to be actual studies of student affect. In addition, the studies conducted by Telese, McMullen, and Kulm were actually part of the same research project with the researchers sharing the data but reporting the results separately. That leaves five studies with a component of student affect, Borasi and Rose (1989), Lesnak (1989), Owings and Follo (1992), Powell and Lopez (1989) and the combination study by Telese, McMullen, and Kulm (1993). One of these studies used portfolios as their sole

vehicle for looking at affect, while the Telese, McMullen, Kulm study included several teachers using portfolios alone or in combination with other alternative assessment strategies. Four of the five studies (Borasi & Rose, 1989; Lesnak, 1989; Powell & Lopez, 1989; combination study by Telese, McMullen, and Kulm, 1993) had a similar focus to the study proposed here; each of these studies tried to determine students' perceptions about some aspect of the assessment method being used rather than just trying to determine whether the method changed the attitudes or feelings of students. These studies that contained both student affect (perceptions) and alternative assessment in mathematics, including portfolios, will be examined in the next section.

The Students' Perceptions Component

Regions A, B, and D from Figure 1 (page 8) are yet to be examined. The proposed research lies in region A with no studies found that would be contained in this region at the intersection of the NCTM recommendations for assessment reform, students' perceptions, and portfolios, or portfolio-related assessment. Recall that Region B enclosed studies of students' perceptions on portfolios and related assessments. At the end of this section, four relevant studies will be reviewed that lie in this category. Region D contained studies of students' perceptions of the NCTM recommendations for assessment reform, but no studies were found that would fit directly into region D. Therefore, in the first part of this section, two studies that are closely related to this region will be examined.

Since no research was found about students' perceptions of assessment forms advocated by the NCTM, it would be valuable to know how students facilitate or hinder reform attempts made by teachers. It was mentioned earlier in this paper that both Walen (1993) and Ivey (1994) found that students played a critical role in the success of changes implemented by teachers in the mathematics classroom. In both of these

studies, the changes were those recommended by the NCTM in the Curriculum Standards (1989). In a study of an algebra classroom, Walen (1993) reported that student willingness to change was critical in the teacher's efforts to reform her classroom in line with the NCTM Curriculum Standards. Walen stated, "Ultimately, without addressing student concerns for changing the classroom environment, reform movements in mathematics education have little chance of continued success," (1993, p. 226). Additionally, Ivey (1994), in a follow-up to Walen's study, asked the question, "How do students influence the implementation of the Standards [Curriculum Standards] in this classroom?" (1994, p. 13) "This classroom" referred to an eighth grade algebra classroom where the teacher was trying to implement reform according to NCTM Curriculum Standards. Ivey approached data analysis in this qualitative study within the framework of student's world views (Pepper, 1942) and Eisenhart's (1988) theory of how students acquire culture. The findings of her study caused her to conclude: "If students' world views are ignored, or if world views in general are ignored, reform will be much more difficult. Teachers can make structural changes, pedagogical changes, and content changes and still not substantially change the classroom" (1994, p. 142-143). In the study reported here, students compiled portfolios and played a crucial role in facilitating the assessment reform implemented by the teacher.

In addition to knowing how students facilitate assessment reform, it would be valuable to know how students' perceive assessments in general. According to McLeod, much research has been done on teachers' beliefs about mathematics and mathematics teaching but that "we have little information on students' beliefs about mathematics instruction" (1992, p. 581) and, in his discussion of student beliefs relative to mathematics, he made no comments about students' perceptions of mathematics assessment. Of five research studies found with a component of both

portfolios, or portfolio-related mathematics assessments, and students' perception (Owings & Follo, 1992; Telese, 1993; Borasi & Rose, 1989; Lesnak, 1989; Powell & Lopez, 1989), none focused on students' perceptions of how the assessment could be used to demonstrate their learning. In a study of six fifth-grade students using mathematics portfolios and six fifth-grade students not using portfolios, Owings & Follo (1992) found that portfolio students did not attribute their grades to internal factors, such as their own abilities or effort, any more often than the students who were not using portfolios. The researchers did not ask the students what they thought about portfolios as an assessment tool. Telese (1993) tried to determine whether students perceived changes in instruction made by teachers using alternative mathematics assessments. Students were not asked for their perceptions about any of the assessments. Borasi and Rose (1989) asked the question of whether students thought they learned more mathematics by using journals as a learning tool. Students were not asked for their ideas on whether the journal demonstrated their learning. Lesnak (1989) wanted to find out what students thought the benefits were of using writing in mathematics. Students did not mention that journals were valuable for demonstrating their learning. Finally, Powell and Lopez (1989) wanted to know whether writing increased students' understanding of mathematics and produced more positive attitudes towards the subject. Again, students were not asked to evaluate mathematics writing as an assessment tool. These five studies lie in region B, but not in region A, since students were not asked to provide their perceptions about the portfolios or writing in mathematics as an assessment tool. In addition, of four studies found by the researcher dealing only with portfolios in mathematics (Hearne & Schuman, 1992; Koretz et al., 1992; Leitner & Trevisan, 1993; Owings & Follo, 1992), not one researcher asked students what they thought about using portfolios as an assessment tool. However, two studies asked teachers what they thought students thought about portfolios in

general (Leitner & Trevisan, 1993; Koretz et al., 1992). Due to the lack of research studies about students' perceptions of portfolios as an assessment tool in the spirit of the NCTM reform, region A, the researcher will examine four studies from region B for the data collection methods.

The first study, conducted by Telese, contained components of assessment, student affect, and the NCTM reform movement at the high school level (although not all the students were high school age). The researcher used 387 students, grades four through ten, of eighteen teachers, who were participating in the Innovative Mathematics Assessment and Teachers' Classroom Practice (IMAP) project and who were trying to implement new methods in line with the NCTM Curriculum Standards. The teachers selected one or more alternative assessment methods to experiment with in their classrooms. Of the eighteen teachers, seven were high school teachers and five of those used journals or some form of mathematics writing. Three teachers in grades four through eight used portfolios. Telese had two research questions, one of which was: "To what extent will students perceive changes in the modes of instruction used by teachers who use alternative assessment techniques?" (1993, p. 8). Three times during this year long study, Telese administered an instrument, of his design, having 25 statements with a five-point Likert scale. Telese used a quantitative analysis finding that students did perceive a change in the teachers' instruction. This was consistent with McMullen's results where observations of the teachers showed that they did change their instructional methods. (Recall, McMullen and Telese shared the same teacher and students.) However, students did not make personal comments about their experiences but were limited to the questionnaire. More detailed data on student perceptions could have been gathered by giving an open-ended questionnaire and/or interviewing students.

In contrast to the Telese study, three studies, using writing in mathematics as an alternative assessment and/or instructional strategy, used written reports and/or interviews, not questionnaires, to gain more complete data on student perceptions. However, the students were asked for their perceptions of writing as a learning tool, not an assessment tool. These studies showed that the examination of journal writings can provide valuable data about student affect. The three studies were all at the college level, but the classes studied were remedial mathematics courses similar to first and second year high school mathematics classes. Two specifically addressed using "writing-to-learn" activities. "Writing to learn" in science or mathematics classes is most basically about developing students' conceptual understanding of these subjects by developing their capacity to use the languages of these field fluently" (Connolly, 1989, p. 4).

The first study of writing and mathematics showed the value of using qualitative methods in gaining information on students' perceptions. Initially, Lesnak (1989) wanted to know if using writing-to-learn would increase students' academic achievement in a remedial college algebra course. However, as the study progressed, he decided to analyze data qualitatively, as well. The students were from four semester-long basic algebra classes consisting of 26 students each; two were control groups and two were experimental. Ten percent of the students had never taken algebra and the other ninety percent had taken at least one year of high school level algebra with little success. Many students had math anxiety and felt they suffered from "math blocks," a term used by the researcher.

Lesnak was the instructor and the researcher for this study. He planned the course so that the writing-to-learn activities were an integral part of the two experimental classes. At first, the students were reluctant and at times "hostile" (he reported) about being required to write in a mathematics course. His plan focused on

three points: he would not evaluate their writing, he convinced them that they had previously been unsuccessful in mathematics so the old teaching methods must not have been effective, and he used his enthusiasm and commitment to the idea that writing would help them to overcome "math blocks" to encourage them to participate. Therefore, he was using writing as both instruction and assessment.

The quantitative analysis was carried out by comparing the final mean average for the classes, experimental versus control. He found a statistically significant difference in the scores, with the average of the experimental classes being higher. The qualitative analysis of written course evaluations completed by the students showed that all fifty-two students responded positively to the experience, even eight students who had failed the course. Some of the benefits of the writing experience, given by students, were that writing helped them to overcome "math blocks" and reduce math anxiety. Lesnak stated:

The main objective is to improve the learning environment through improved teaching and teaching techniques. If the only means by which this objective can be accomplished is through qualitative research, then this type of research should be encouraged at all levels of instruction. (1989, p. 156)

Lesnak, then, was impressed by qualitative research methods. However, he did not use interviews which would have given him even more detailed information.

The second writing and mathematics study, conducted by Powell and Lopez, was a case study. Powell, the instructor of the course, collaborated with one student in the class, Jose Lopez, to describe the process and results. Powell pointed out the unique structure of this study. Usually, there is a researcher and the objects of the researcher, where the researcher may even be the instructor. In this study, however, the instructor and the student worked together to analyze the writings and the results.

Powell felt that students learn by reflecting on experiences and that in mathematics classrooms, "there are few, if any, situations in which students are asked

explicitly to reflect on the mathematics they are doing, their feelings about mathematics, or themselves in relation to the discipline" (1989, p. 157). (His idea closely parallels the ideas of self-selection and justification of items in the portfolio used for the study reported here.) However, Powell felt that writing in mathematics was best used as a tool for learning mathematics not just as a measure of student's understanding. His theory was that writing can be a "vehicle to learn mathematics."

Powell's main research question was "What changes could be observed in students' understanding of and feelings towards mathematics through their writing?" (1989, p. 161). Powell's research question is in contrast to this study. This study examined students' perceptions as they exist not changes in students' attitudes. However, as will be seen, other issues in Powell's study are relevant to this study.

The class taking part in Powell's study was one section of a college mathematics course consisting of basic computation and elementary algebra with most students having negative feelings and beliefs about mathematics due to prior achievement and experiences. Powell hoped that the writing activities would "empower" these students in two ways:

(1) to promote students' awareness of and facility in the use of writing as a vehicle for learning, and (2) to put students at the center and in control of their own learning by engaging them in reflection and critical reflection on mathematical experiences. (1989, p. 162)

These purposes were similar to this study, where students were asked to select and reflect on items for their own portfolios.

Results of the Powell and Lopez study were that: the teacher benefited from feedback provided by the student; journal writing promoted critical thinking for the student; and writing provided students with the stimulus to become active rather than passive learners. The study reported here required active student participation and critical thinking in compiling the portfolio. The design of the Powell and Lopez study

allowed for the student, Lopez, to provide Powell with very detailed data on his experiences with writing since the two collaborated in the study, providing an endless opportunity for "interviewing." It was limited, however, because data was gathered from only one student.

The final study to be considered here was conducted by Borasi and Rose (1989). They were interested in changes in attitude, but also in students' perceptions. The researchers contended that many students feel that mathematics is just the acquisition of facts and algorithms to be applied to given mathematics problems. In order for students to find mathematics meaningful and to use it creatively, they must change their conceptions about mathematics and learning mathematics. Borasi and Rose believed that writing-to-learn activities provided part of the answer in changing the students' beliefs. In addition, journal writing was seen as a way to engage the students actively in constructing meaning. The study was qualitative and the researchers hoped to understand the benefits of journal writing upon instruction in mathematics. They chose not to predict the outcomes by stating hypotheses, but to identify working hypotheses for the study. Their working hypotheses were: "what [are the] opportunities for learning mathematics journals can offer, and what conditions may affect how students and teachers actually take advantage of any such opportunity" (1989, p. 350)? The point of their study, then, was not to predict the outcomes of using journals, but rather to analyze the potential of journals in helping students. Similarly, the study reported here attempted to determine the potential of portfolios not to predict outcomes.

The Borasi and Rose study was conducted with a teacher and her students in a college mathematics course, designed for business majors, at a small four-year liberal arts college in the United States. Originally there were 29 students, but only 23 participated regularly in the journal writing and completed the final evaluation. The

students had to write in their journals three times per week with the journals collected and commented upon weekly by the instructor. The grading of journals focused on the frequency and amount of writing not on the content or mechanics of writing. The format was open, but the students requested and were given some suggested topics for the entries. At the end of the semester the students responded to a written evaluation, consisting of three open-ended questions:

1. How has writing in your journal affected your learning of mathematics?
2. How do you feel about journal writing for this course?
3. What are the benefits of journal writing for mathematics classes?
4. How could journal writing be changed to be more effective? (1989, p. 351)

The data for analysis consisted of the twenty-three journals and the evaluations at the end of the semester. In addition, the instructor's reactions to the journal writing experience were used. The data were analyzed for recurring patterns and compared to existing theories of writing and learning. The benefits to the students, reported by Borasi and Rose, were: therapeutic value with students revealing feelings and attitudes, increased learning with students identifying their misunderstandings and making connections among topics, improvements in problem-solving and learning with some students identifying study habits and ways to improve those habits, and changes in students' conceptions of mathematics with some students reflecting upon those changes. The teacher's reading of the journal also provided some benefits: (a) It was a way that the teacher could spend time with each student, if only on paper. (b) The teacher could identify student problems and misunderstandings and chart the progress of the student. (c) The teacher could obtain feedback on lessons and possibly correct instruction both for short and long-term. Using journals, the researchers felt, contributed to the following:

Students may start looking at teachers and schooling in a new light. . . . The journals can also positively influence the student-teacher interaction and classroom atmosphere; when students and teachers freely communicate and see each other as caring human beings, the classroom can turn into a more pleasant environment where all members become partners in learning. (p. 362-363)

The student – teacher dialogue that developed allowed the researchers to gather very detailed information. However, student interviews were not used and would have contributed to the data that they collected.

In summary, the student played a crucial role in the study reported here as the one who provided information about the use of portfolios as an assessment tool. As was seen by examining the literature, little is known of what students think about alternative mathematics assessments. An informal teacher report in the Mathematics Teacher (1994) focused on students' perceptions of alternative assessments in one mathematics classroom. Linda Wilson reported on a case-study research project that she had conducted in 1992. She observed a teacher of second-year algebra who worked in a district where reform, particularly of assessment, was a major issue. In this classroom the teacher constantly assessed students and emphasized to students that they could assess their own work. The teacher "used several authentic assessment practices, including observing, interviewing, and asking students to write about mathematical concepts and their knowledge of them" (Wilson, 1994, p. 413). The writing she asked students to do that promoted self-assessment or higher-order thinking was not counted in her grading scheme. As a result, students did not realize that writing was a part of their mathematics class. Wilson reported, "Only those tasks or activities that were reviewed and then recorded in the grade book received any effort or recognition" (1994, p. 414). She pointed out that students "value only those items that get graded" (1994, p. 414). Her conclusion was that high school mathematics teachers must incorporate multiple sources of information into their grading plan if they

want those sources to be effective for gathering valuable information about students. Wilson's report shows that students have some opinions on grading and alternative mathematics assessment, but the report does not clarify what students think of these assessments as a demonstration of their learning.

Conclusion

From the review of literature it was seen that there is a "paucity" of research on students' perceptions of portfolios as an assessment tool in the mathematics classroom. However, studies and other literature did confirm that mathematics portfolios are an area worth researching. Comparing portfolios with the six standards found in the Assessment Standards (1995) showed the potential of portfolios as an assessment tool reflecting the NCTM's vision of assessment.

Some "big ideas" about portfolios, and portfolio-related assessments, were found in the literature. First, alternative mathematics assessments were found to interact with instructional methods by producing changes in instruction (McMullen, 1993; Telese, 1993; Kulm, 1993; Flexer & Gerstner, 1993; Leitner & Trevisan, 1993; Koretz et al., 1992; Aschbacher, 1992; Borasi & Rose, 1989). If teachers have poor attitudes towards alternative assessments, it would be expected that they would not use them. However, it was found that alternative mathematics assessments were met with positive responses from teachers in empirical studies (Koretz et. al, 1992; Aschbacher, 1992; Kulm, 1993) and in informal reports (Knight, 1994; Milliken, 1992). In addition, positive student responses to alternative mathematics assessments were reported (Telese, 1993; Kulm, 1993; Leitner & Trevisan, 1993; Koretz et al., 1992; Aschbacher, 1992; Borasi & Rose, 1989; Lesnak, 1989; Powell & Lopez, 1989), which may indicate that students will use these assessments in the classroom. Two

more significant findings from the literature review are that students are critical in reforming the mathematics classroom (Walen, 1993; Ivey, 1994) and that the recommendations for reform issued by the NCTM have not yet been fully implemented (Garet & Mills, 1995). This leads the researcher to believe that more research is needed to inform mathematics educators and to help facilitate the reform movement.

Looking at the research studies prior to the design of the study reported here provided good information on designs and methods that would best answer the research question. Qualitative designs were effective in answering similar research questions and it was also seen that student interviews, classroom observations, and open-ended questions on perceptions would have given some researchers a more complete picture of students' perceptions. Examining written student documents was noted as very valuable by researchers. However, researcher as instructor may have been a problem in several studies.

Finally, examining the literature points to a huge gap in knowledge. No studies were found that asked students for their perceptions of mathematics portfolios, or any other alternative assessment for that matter, as a tool for demonstrating their progress in fulfilling the NCTM student goals of valuing mathematics, becoming confident in mathematical ability, becoming a mathematical problem solver, learning to communicate mathematically, and becoming a mathematical problem solver.

CHAPTER 2 DESIGN AND METHODOLOGY

The use of alternative assessments in the mathematics curriculum is expanding throughout classrooms across the United States. Student portfolios are one of these assessment types. This study views portfolio use from the student's perspective. The research question was: What are students' perceptions about portfolios as a tool for assessment, that is, for demonstrating their progress in fulfilling the NCTM goals for students? The purpose of the study was to explore the use of portfolios to inform mathematics educators about the potential of portfolios as an assessment tool.

Due to the exploratory nature of the question, a qualitative design was planned and carried out. Questionnaires, classroom observations, and interviews were utilized to gather information about the students in this study. In addition, written material produced by the participants was analyzed. This chapter will describe in detail the subjects, methods, data collection procedures, and the type of data analysis employed by the researcher in answering the research question.

According to Patton:

Qualitative inquiry designs cannot be completely specified in advance of fieldwork. While the design will specify an initial focus, plans for observations and interviews, and primary questions to be explored, the naturalistic and inductive nature of the inquiry makes it both impossible and inappropriate to specify operational variables, state testable hypotheses, and finalize either instrumentation or sampling schemes. A qualitative design unfolds as field work unfolds. The design is partially emergent as the study occurs. (1990, p. 61)

In some ways the design was partially emergent. Interviews focused upon student work that was generated during the semester. It was never possible to anticipate what would be written by the students. Observations were scheduled by the researcher, often on short notice, because of the variability of schedules that occur in any school.

The teacher occasionally changed her plans about portfolio work days and the researcher had to adjust observations to accommodate the changes.

Subjects and Setting

The subjects of the study were three high school seniors from the same mathematics classroom. The high school, with enrollment of about 200 students, employed two full-time mathematics teachers. The students in this school were predominantly white and middle class, as were the three focus students. The population of this ranching community was fairly stable with many students attending the same school for their entire high school career. The students were using the SIMMS mathematics curriculum, to be described in more detail later in this section. These students were unique in their school because they were in the only SIMMS class being taught there. The majority of students in this class, at the time of the study, had taken SIMMS from the ninth grade year on and were now seniors. (More detail on the class will be given in Chapter 3.) The choice of SIMMS students was made as a matter of convenience for the researcher who was a member of the SIMMS Assessment Team at Montana State University in Bozeman, Montana.

The site was selected during the 1995 SIMMS summer Teacher/Leader Institutes held at Montana State University in Bozeman, Montana. These workshops were designed to train teachers in using the SIMMS materials. As it turned out, the teacher selected was very familiar with the SIMMS materials. She was in her fourth year of piloting the materials and as a result had taught with them before. She was an experienced, certified high school mathematics teacher and had implemented mathematics portfolios the year before as part of an informal portfolio research study conducted by the SIMMS Assessment Team. She planned to continue the use of

portfolios during the 1995–96 school year. The teacher readily agreed to the terms set forth by the researcher. Those terms were: (a) to provide the researcher with a written plan for a teacher-directed portfolio, including the goals the teacher hoped students would achieve through the use of portfolios; (b) to allow students some freedom in selection of items for the portfolios, within guidelines set by the teacher, and to require the students to write a justification of each selection; (c) to assist the researcher in collecting the student permission forms; (d) to be interviewed three times; (e) to allow focus students to be interviewed three or four times; (f) to administer a questionnaire twice during the study; (g) to allow the researcher to observe the classroom; (h) to discuss weekly on the telephone any classroom occurrences relating to portfolios; (i) to have the students compile special NCTM Goals Portfolios (to be described in more detail in the data collection section) twice during the semester; and (j) to allow the researcher to collect and review the NCTM Goals Portfolios before the teacher assessed them.

The Systemic Initiative for Montana Mathematics and Science (SIMMS)

“SIMMS is an integrated mathematics program that emphasizes the relationships among topics within mathematics as well as between mathematics and other disciplines” (SIMMS, 1994, p. 2). The five-year project is a partnership of the Montana Council of Teachers of Mathematics (MCTM), the Montana Legislature, the Office of Public Instruction, the Montana University System, the Montana Science Advisory Council, the National Science Foundation, and Montana businesses. The project is funded mainly by the National Science Foundation and the state of Montana. The initial grant for the Project ends on August 31, 1996, but an extension grant remained a possibility during the fall of 1995. In the final year of the Project, Simon and Schuster Custom

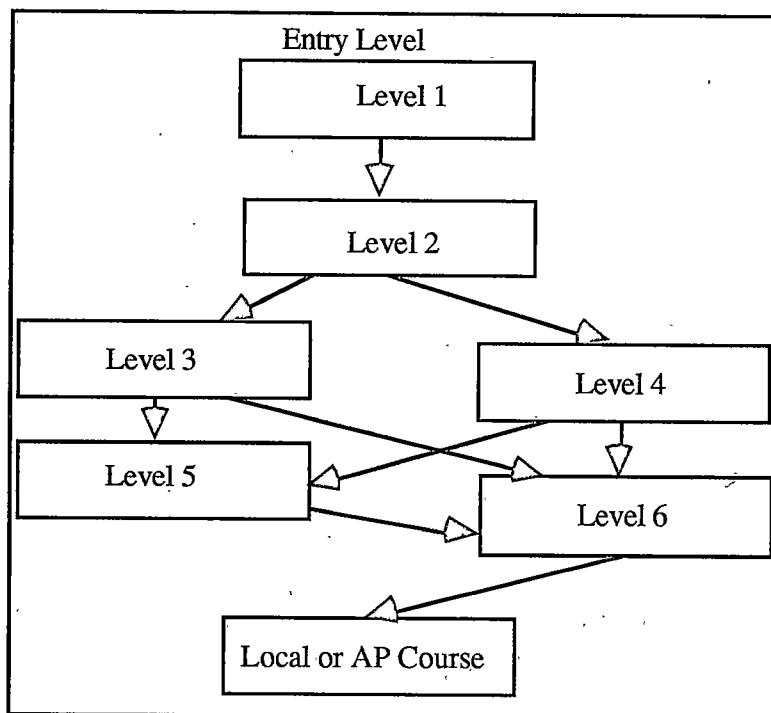
Publishing purchased limited rights to print and sell the materials. During the 1995-1996 academic year, the SIMMS Project personnel were in the process of finishing the final writing and editing of curriculum materials (similar to textbooks) for this innovative, integrated high school mathematics program. The materials were referred to as integrated because algebra, geometry, statistics, probability, and other areas of mathematics are included each year, not isolated like some mathematics curriculums into courses on algebra, geometry, and so on. The materials were considered innovative because most modules (units of study similar to chapters in a textbook) were centered around a context, such as population growth, geometric shapes of natural crystals, or applications of trigonometric functions, and almost all homework problems were applications, not just computations.

In addition to designing and publishing a written curriculum, the SIMMS project had the following goals:

- promote reform in science and mathematics education
- redesign the 9–12 mathematics curriculum using an integrated, interdisciplinary approach for *all* students
- develop and publish curriculum and assessment materials for grades 9–16
- incorporate the use of technology in all facets and at all levels of mathematics education
- increase the participation of females and Native Americans in mathematics and science
- establish new certification and recertification standards for teachers
- redesign teacher preparation programs using an integrated, interdisciplinary approach
- develop an inservice program on integrated mathematics to prepare teachers of grades 9–16
- develop the support structure for legislative action, public information, and general education of the populace necessary for effective implementation of new programs. (SIMMS Project [brochure], n. d., p. 1)

The curriculum materials were written by high school mathematics teachers in cooperation with university professors and were being used with approximately 7500 Montana high school students on a full or part time basis during the 1994-95 school year. (Hirstein, 1995, SIMMS Assessment Committee Meeting) There are six levels of SIMMS materials, referred to by the Project as Level 1, Level 2, Level 3, Level 4, Level 5, and Level 6, with 16 modules in each level. Levels 1 and 2 were designed for all students, Levels 3 and 5 were for non-college bound students, and Levels 4 and 6 were college preparatory classes. The following diagram shows how the levels may be chosen by a student, if a school used all six levels.

Figure 2: Figure similar to SIMMS diagram of levels (SIMMS, 1994, p. 3).



The school in which this study was conducted offered only one SIMMS class. The students in this class had begun with the program during their ninth grade year in

the fall of 1992. No other SIMMS class had been offered since and it was not clear during the semester of this study whether any other SIMMS class would ever be offered at the school. The students in this study were using Level 4 and 5 materials and were classified by the school as Level 5. During the previous year, the class had used Level 3 and 4 materials, but had been classified as Level 4 to satisfy requirements for students intending to enter college. The students had all fulfilled the school requirement of three years of high school mathematics and, therefore, this senior year of mathematics was an elective. The class was composed of nine students and met during the last period of the school day.

Methods

"Case study design refers to the one phenomenon the researcher selects to understand in-depth regardless of the number of settings, social scenes, or participants in the study" (McMillan & Schumacher, 1989, p. 392). This research study was a case study of portfolios in one setting with three focus students. Qualitative research methods were chosen as the best way to examine the perceptions of the students about the phenomenon under investigation. The researcher strove to demonstrate the characteristics of qualitative research that are identified by Bogdan and Biklen (1982).

1. Qualitative research has the natural setting as the direct source of data and the researcher is the key instrument.
2. Qualitative research is descriptive.
3. Qualitative researchers are concerned with process rather than simply with outcomes or products.
4. Qualitative researchers tend to analyze their data inductively.
5. "Meaning" is of essential concern to the qualitative approach. Researchers who use this approach are interested in the ways different people make sense out of their lives. (Bogdan & Biklen, 1982, p. 27-29)

The students were observed in their natural environment, the classroom, and were interviewed at the school during normal school hours. All of the student interviews were conducted during the students' study halls. The researcher was the "key instrument" for data collection and analysis. The focus of this study was the process of students using portfolios and their perceptions about that experience. Student portfolios were examined, but the portfolios, the products of this process, were not the focus of the study. What was found in the portfolios served to help the researcher identify themes and to further explore what actually occurred during the course of the semester-long study. In this study, portfolios can be thought of as the vehicle through which the researcher gathered information about students' perceptions. Interviews, observations, and other data collection methods evolved as the study unfolded, characteristic of an inductive approach. The researcher investigated "meanings" constructed by the participants: the perceptions of students about the portfolio as a display case for demonstrating the attainment of NCTM student goals.

As data was collected it was analyzed using the constant comparative method suggested by Bogdan and Biklen (1982, p. 68). Data analysis was begun by the researcher during the first month of the study and continued throughout the study. Data collected constantly focused and refocused the next collection procedures. For example, interview questions often focused on students' written responses.

Data Collection

In order for students to compile portfolios, they must have adequate time to generate items for inclusion in that portfolio. It is also advantageous to allow the students and the teacher some time to experiment with the process involved in selecting and justifying portfolio contents. For these reasons, the length of the study was one

high school semester of 90 school days. The teacher and one of the focus students were familiar with the portfolio process.

The semester began during the last week of August, 1995, and ended on January 19, 1996. The data collection can be viewed in four distinct phases, which were not of the same length. The purposes of the first phase were to gather baseline data on the students, teacher, and classroom; prompt the students to think about the NCTM student goals; and initiate the students into the process of compiling portfolios. The purpose of the second phase was to allow the students to "practice" using portfolios by focusing first on compiling portfolios with guidelines set by their teacher and, then, to use their ideas about the goals of the NCTM to compile a special portfolio to be referred to as NCTM Goals Portfolio I. The purpose of the third phase was for the students to compile a final portfolio after having had the time to reflect on the previous portfolio. This final portfolio is referred to as the NCTM Goals Portfolio II. The purpose of the fourth phase was to verify results of the study. These four phases are examined in the first part of this section and in the latter part, each data collection method is described.

Phase One

During the first week of school, the permission slips were distributed, signed, and by September 18, they were all returned with the students being given a questionnaire requesting their thoughts on the NCTM goals. The teacher was also interviewed during the second week of school. The researcher analyzed the questionnaires to guide questioning in the first student interview. Three classroom observations were conducted by the researcher, including the day that the teacher introduced the portfolio scheme to the students. The idea of portfolios was not new to the majority of the students in the class. On the first researcher observation day, the

teacher had the students reflect in writing on their previous portfolio experiences in mathematics.

The researcher collaborated with the teacher to select three focus students during the third week of September. The selection was done to be representative of the class make-up with consideration being given to the willingness of the students to participate in the interviews (The characteristics of the students will be discussed more fully in Chapter 3.). In addition, the researcher's committee suggested that the teacher recommend three students who were unlikely to leave the class during the semester. Because of the uncertainty of working with the lives of people, other events affected the selection of the students. Five students were initially identified by the teacher and the final choice was affected by two chance occurrences. One of the students had to drop out of school for health reasons and the other was dealing with a serious illness in her family causing her school attendance to be sporadic, at best. At that point the selection of the three students was no longer a question. The students selected provided a well-rounded view of the portfolios. The only male in the class at the time was selected and he had previous experience with both SIMMS and portfolios. The second student was a female who had been a SIMMS student at this school during her ninth and tenth grade years. She had moved out of state during her eleventh grade year and enrolled in a geometry class. She returned to this school and SIMMS mathematics for her final year in high school. Therefore, during the year of this study, she had limited portfolio experience, but had at least been introduced to the idea of portfolios at the beginning of the previous year. The third student was a female who was new to the SIMMS mathematics curriculum and to the use of portfolios. Her teacher determined that she had the necessary prerequisite mathematical skills to take a fourth year SIMMS class.

After the selection of focus students, the first focus student interviews were conducted on September 26, 1995, to gain student background details and to clarify the

answers given by the focus students to the questionnaires. During phase one, the students worked on the portfolio designed by the teacher and the researcher was sent the selections from all the students. The researcher contacted the teacher at least once per week, and in several cases, more than once per week, to check on any happenings related to portfolios. A log was kept of these calls and the researcher maintained field notes of pertinent information given by the teacher. Phase one ended on September 26, 1995, with the first student interviews completed.

Phase Two

The students continued to work on portfolios, the teacher sent along student work to the researcher, and the researcher maintained, at a minimum, weekly contact with the teacher. In addition, the teacher was asked to suggest critical days for researcher observations. These critical days included, but were not limited to, special portfolio work days and days when the teacher planned to clarify anything about portfolios. Five classroom observations were carried out during the first two phases. Six observations were planned, but inclement weather prevented one of the visits. On October 24, 1995, the teacher introduced the NCTM Goals Portfolio I at the very end of the class period and did not mention it again to the students until November 1, two days before the portfolio was due. The researcher was present in the classroom on October 24, but November 1 was the day that weather prevented another visit. The teacher planned to collect the portfolios on November 3, the end of the first quarter, but decided to postpone the due date until November 5. The researcher picked up the portfolios at the site on November 9, but there were still two missing from the class of nine. However, the focus students all turned in their portfolios. The researcher then analyzed all the portfolios, particularly those of the focus students, in preparation for the second interviews. Two of the focus students were interviewed on November 15

and the third student was interviewed later on November 30 due to illness. The student portfolios guided the interviews. The second phase ended on November 30, with the second teacher interview. The teacher interview occurred quite late because the teacher was ill during November, school was canceled for several days for basketball tournaments, and Thanksgiving was also observed. In the November 30 interview, the teacher was asked to reflect on the portfolio process and how students had been progressing in light of her goals for the students and the attainment of NCTM student goals. The researcher referred to the students' portfolios during this interview.

Phase Three

During the third phase, which officially commenced on December 1, the students continued to work on portfolios according to teacher guidelines. The researcher maintained weekly contact with the teacher, and observations were scheduled for critical portfolio days. The teacher sent the researcher student selections from the teacher-directed portfolio. Five observations were conducted during this phase. The teacher collected the NCTM Goals Portfolio II on January 8, 1996, and the researcher collected them at the site portfolios on January 11. The final student and teacher interviews were conducted on January 12 before the teacher returned comments and grades to the students. The student portfolios were used to guide these interviews. This was the end of phase three. On this date, the researcher formally ended observations and collection of portfolio materials.

Phase Four

Phase four included the administration of the final student questionnaire and the student portfolio presentations planned by the teacher on January 17, 1996. The teacher asked the students standard questions about their portfolios. The researcher

was in attendance and also posed questions to the students as necessary to clarify their responses. These student presentations were an unanticipated data collection opportunity. The researcher examined the final questionnaire responses and determined that no further interviewing of students was necessary. The data collection ended and the researcher exited the site.

The following table summarizes the data collection methods employed during the four phases.

Table 2: Data collected in each phase.

	NCTM Goals Question- naire	Teacher interviews	Focus student interview	Classroom observa- tions	Students work on teacher- guided portfolio	Students work on NCTM Goals Portfolio	Phone calls
Phase I	1st	1st	1st	3	X		X
Phase II		2nd	2nd	2 (3 had planned)	X	X	X
Phase III		3rd	3rd	5	X	X	X
Phase IV	2nd		not needed	1			

Throughout the data collection period, the data was analyzed for themes or patterns and the collected data served as a springboard for interview questions and further data collection. Data from interviews, student work, teacher comments, and observations were compared to triangulate the data and to verify what occurred.

NCTM Goals Questionnaire

The NCTM Goals Questionnaire was administered twice to all students in the class. The first time was on September 5, 1995. The second time was on January 17, 1996. Responses on the first questionnaire were immediately analyzed by the researcher after receiving them from the teacher. The first questionnaire served three purposes: (a) to guide the first interview of focus students that occurred on September 26; (b) to provide triangulation of data with the interview responses, written work and responses, and the classroom observations; and (c) to allow students to begin to formulate ideas on the NCTM student goals for the second phase of the study when they were asked to compile the NCTM Goals Portfolio I.

The NCTM goals for students provided the framework for the questionnaire consisting of ten open form questions. "Open form" questions are those "in which the subjects write in any response they want" (McMillan and Schumacher, 1989, p. 258). As an example, two questions were "What does it mean to value mathematics?" and "How do you show someone else that you value mathematics?" The other eight questions followed a similar parallel form using each goal. (See Appendix C for the Student Questionnaire.) When the students made their selections for the NCTM Goals Portfolio I, the teacher handed out forms for each goal. For example, she gave each student an entire sheet of standard-sized paper with the heading: "Students will learn to value mathematics." The students were then to find an appropriate piece of work, write their explanation for choosing it as their example of valuing on the form, and attach the form to the selection.

The teacher made similar forms for the NCTM Goals Portfolio II, but she expanded the directions to read: "Write at least one good paragraph to explain why the attached item is evidence that you value mathematics." The students were instructed to

do one of three things with this sheet. If they were satisfied with the selection and justification they had used for the NCTM Goals Portfolio I, they could just discard the new sheet and hand in what they had originally written. If they wanted to edit their original justification, they could edit and recopy the justification on the new sheet and staple it to the selection. If they did not like what they had before or had not completed it, they would write their new justification on the sheet and staple it to the selection.

Interviews

Teacher. The classroom teacher was formally interviewed three times during the study. The formal interviews were audio-taped, with permission of the teacher. The interview tapes were transcribed within two days of the interview and field notes were written to record any other information from the site visit. In addition, the researcher telephoned the teacher at least once per week for an informal interview and notes were taken and kept in a log. Whenever feasible, the calls were made on the same day and time each week. The time selected by the teacher was during her preparation period in the morning which was about 10:30 a. m. Several times the teacher also called the researcher.

The formal interviews served three purposes: (a) to provide triangulation of data with the classroom observations and the student data, (b) to provide the teacher with an opportunity to reflect upon the use of portfolios, and (c) to allow the teacher to feel a part of the research. The interviews seemed to be a valuable forum of reflection for both the teacher and researcher. Each of the three interviews had a slightly different focus.

The first interview, conducted on September 6, 1995, provided background information about the teacher in relationship to mathematics teaching. In addition, the researcher clarified the teacher's purposes for using portfolios and her goals for herself

and the students. The teacher was also asked to provide her own definitions and thoughts on the NCTM goals for students. Some of the questions for this interview were:

Please describe your history as a mathematics teacher.

What is your view of the purpose of high school mathematics education?

From your own personal experience, how do students learn mathematics best?

For what purposes do you plan to use portfolios in your classroom?

What does it mean to you to value mathematics?

The second interview, given on November 30, 1995, after the teacher had assessed the NCTM Goals Portfolio I, provided information on how the teacher thought the portfolios had been working. The teacher also reflected upon the portfolio experience in relationship to her goals for the students. In addition, the interview focused on the actual student portfolios that the teacher had assessed. Some of the questions for this interview were:

Have you talked directly to your students about definitions for the NCTM goals?

What are your overall impressions of the portfolios that you picked up at the end of the quarter?

Did anything that was in any of the portfolios surprise you?

If you could change anything that has happened with the portfolios this year, what would it be and how would you change it?

The third interview was conducted on January 12, 1996. This interview, like the second interview, took place after the teacher collected and assessed the NCTM Goals Portfolio II. The questions included teacher reflection on the implementation of the portfolios, how the teacher's goals for students were met, and how the NCTM Goals Portfolio II addressed the NCTM student goals.

The telephone interviews served three purposes: (a) to help the teacher feel like a part of the research study, thus, encouraging the teacher's continued efforts in maintaining the portfolios; (b) to help the researcher monitor the study by determining when the most opportune times were for observations; and (c) to have the teacher relay any comments or discussions that occurred in the classroom concerning the portfolios since it will not be possible for the researcher to attend every class period during the study. The informal telephone interviews proved to be very valuable. For example, one telephone call in particular on November 1, 1995, was quite critical to analyzing what happened with the NCTM Goals Portfolio I. The researcher had planned a visit on that day, since the teacher was intending to have the students work on the portfolios. A storm prevented the researcher's visit, however, and she called the teacher immediately after class. Even though the teacher had planned to have a portfolio work day, she had spent most of the class period reviewing for a test. With only about 20 minutes left in class, she passed out the sheets on which the students were to write their justifications for their selections. When one of the focus students saw the NCTM student goals, he said, "I am really sick of this." The teacher reported to the researcher that most of the other students seemed to be in agreement with this student. The informal telephone interviews also became a time for the teacher to discuss, with the researcher, her frustrations. In particular, at the beginning of the year the teacher was struggling with the material in the first modules that she was teaching. The teacher seemed grateful to have someone with whom to discuss these problems.

Student. The focus students were formally interviewed three times during the study. The purposes of the interviews were: (a) to provide triangulation of data with the classroom observations, the NCTM Goals Questionnaire, student's written work and comments, and the teacher interviews; (b) to provide the student with an

opportunity to reflect upon the use of portfolios; and (c) to clarify the selection of items in the portfolio. Each of the three interviews had a slightly different focus, but a common thread through all three was the NCTM student goals. All of the students granted permission for the researcher to audio-tape the interviews. Transcriptions of the interviews were completed within two days following the interviews which kept the setting and tone of the interviews fresh in the researcher's mind. Field notes were written on the day of the interviews to describe any other information that was not included formally in the tape. The researcher was able to quickly begin analysis and comparison of the interview data with other data.

The first interview, given on September 26, provided background information on each student in relationship to mathematics. This interview was also used to establish rapport with the focus students. The students were very willing to talk to the researcher and two of the three students thanked the researcher at the end of the interview. The researcher clarified unclear responses from the NCTM Goals Questionnaire. Some examples of the questions for this interview were:

Suppose I am a new student in your math class this year and I have never done a portfolio. How would you describe a portfolio and what I need to do to put one together?

Do you find mathematics useful out of school?

How would you rate yourself as a mathematical problem solver?

The second interviews were conducted on November 15, 1995, for two students and on November 30, 1995, for the third student who had been absent. The interviews provided information on how the student viewed the portfolio process and how selections addressed the NCTM goals. The students were asked to refer to their NCTM Goal Portfolio I during the interview. Some examples of the questions for this interview were:

I had planned to visit your class on the day that you worked on portfolios. Since I was not there would you tell me how working on your portfolio went for you?

How does your teacher grade your portfolio?

Why do you think you are putting together portfolios in this class?

This interview gave students an opportunity to reflect on what they had gained by working on the portfolio.

The third interview took place on January 12, 1996, one week before the end of the semester. This interview, like the second interview, occurred after the collection and analysis by the researcher of the NCTM Goals Portfolio II, but before the students received a grade from the teacher. The questions focused on item selections and how these reflected the NCTM student goals. Each student had their own NCTM Goals Portfolio II to refer to during the interview.

After the final NCTM Goals Questionnaire was analyzed by the researcher, it was determined that no further interviews were needed. It was particularly helpful that the teacher had the students present their portfolios to the class on January 17, 1996. The teacher allowed the researcher to ask questions of the students, as well.

Classroom Observations

The researcher visited the classroom on days referred to as "critical days." These were days when the teacher would deal directly with the portfolio. During the first, second, and beginning of the third phase of the study this was difficult because the teacher had used portfolios with these students before and commented to the researcher that the students knew what to do, although several students in the class had not used portfolios before. Also, the teacher reported during weekly phone calls that since this class met during the last period of the day and the students were seniors,

there was very high absenteeism due to school sponsored events. She expressed that in a class of nine students, 4 or 5 absent can be very significant. Because of this, she said she was never certain what was going to happen on any particular day. For example, she had planned to have the students look at their last year's portfolios on September 6, and so the researcher planned a visit to the classroom on that day. The teacher was in a hurry to cover some new material because many students had been absent and were going to be absent for athletic events again that week. She allowed them only ten minutes to look at the portfolios and then said they would come back to it. They never did come back to it, but, instead, the teacher had the students fill out a written comment sheet on the portfolios as a homework assignment. The researcher did get copies of the responses.

On October 24, the teacher planned to go over the guideline she had prepared for the NCTM Goals Portfolio I. As a result, the researcher planned another visit for this date. However, on that day the teacher was busy answering homework questions and did not hand out the guideline until one minute before the end of class. There was no discussion of this handout during that class period. She did not refer to the handout again until November 1 when the researcher had planned to visit the site, but was unable to get there due to inclement weather. That day she reported to the researcher only allowing about 20 minutes to work on the portfolio as she wanted to spend ample time reviewing for the upcoming test. The researcher maintained weekly contact with the teacher in order to find out when the students would be working with or discussing portfolios, but there were no other reported portfolio discussion or work days. By the end of the second phase of the study, five observations were carried out, but practically nothing was seen or reported of portfolio work.

Extensive observation notes were taken by the researcher during each observation. The researcher used a two-column format so that her ideas and thoughts

could be recorded in the left-hand column and notes of actual events could be recorded in the right-hand column. (See Appendix C for an example of the observation notes.) After the researcher returned from the site, field notes were written with additional details or reflections about what occurred. (See Appendix C for an example of the field notes.) Informal discussions with the teacher occurred before and after most observations and also during the teacher's preparation period and lunch period on several occasions. This information was recorded in the field notes made for that day and additional information was discussed in the researcher's journal. Immediately after each observation, the researcher analyzed the data from the observation notes and the field notes. The data from observations was used to focus subsequent observations. For example, the researcher noticed that students were asking very few questions about the portfolios. Subsequently, the researcher made a strong effort to write down exact quotations of student portfolio questions asked during class.

The Portfolios

During the semester of the research study, the students compiled two different types of portfolios. The first type was the teacher-directed portfolio which will be referred to as the "Best Piece Portfolio." The second type of portfolio was the "NCTM Goals Portfolio." The second type of portfolio was collected twice, once at the end of the first quarter of the school year (NCTM Goals Portfolio I) and once near the end of the first semester (NCTM Goals Portfolio II). At the outset of the study the researcher differentiated between the NCTM Goals Portfolio I and the NCTM Goals Portfolio II. The teacher preferred to think of the NCTM Goals Portfolio I as a rough draft of the NCTM Goals Portfolio II, feeling this would help the students to see the portfolio as more of a process. The following sections describe the two types of portfolios and discuss the events relative to these portfolios.

Teacher Directed Portfolio. The teacher had used portfolios with this class during the previous school year and chose to continue this practice utilizing last year's format. After a module (unit of study) was completed, the teacher directed the students to place all of their work including notes, quizzes, and tests from the module into a folder that she kept. She then administered the module test, followed by the students selecting one piece of work for the portfolio and answering these questions: "1. Explain why this piece is the BEST!!!! Use complete sentences!!!! 2. What was the criteria you used to pick the best piece of work? Use complete sentences!!!!" (See Appendix C for this form.) Their selections were placed in a separate folder where the teacher occasionally had students place other work that had been completed in class. This was not done on an individual basis because she chose particular assignments for all students to place in the portfolio. Included were some journal writing samples and open-ended mathematics problems that were not a part of any module. This plan was devised entirely by the teacher and included the two points that the researcher had specified in the proposal for this study: (a) allow students some freedom of selection in the items for the portfolio (although the teacher can place some restrictions on the types of entries) and (b) require students to write a justification for the selection of each item (this justification must be included in the portfolio). The teacher-directed portfolio described above will be referred to throughout the remainder of this paper as the "Best Piece Portfolio."

NCTM Goals Portfolio. Two special portfolios were compiled by the students during the semester. The portfolios will be referred to as the NCTM Goals Portfolio I, turned in at the end of the quarter (mid-semester), and the NCTM Goals

Portfolio II, turned in at the end of the semester. These portfolios were compiled by the students independently from the teacher-directed portfolio. At the end of the previous school year, the students had compiled a special portfolio that was very similar to the NCTM Goals Portfolio.

The researcher had given the teacher a sample guideline for the NCTM Goals Portfolios during August of 1995. At this time the guidelines were reviewed and discussed. The teacher decided that she wanted to type her own guideline and make a few minor alterations to the plan. (See Appendix C for a copy of the teacher's guideline adapted from the NCTM Goals Portfolio guideline.) The researcher kept a journal of her thoughts and decisions during the research study. One entry that related to the teacher's decision to alter the NCTM Portfolio guideline was:

She [the teacher] is writing up a page to tell them how they will be selecting their end of quarter portfolio – that is, for the five student goals. She wants them to be able to think about it now so they would have some piece of work in mind. I don't mind at all that she is taking over this portfolio description because it makes me less of an intruder in the classroom. She is planning to add something a little different from my suggested plan. If a student cannot find a piece of work to illustrate a particular goal, then she will have them describe a piece of work that would be appropriate.

The NCTM Goals Portfolio I was collected by the researcher on November 9, 1995. The researcher reviewed the portfolios, conducted the student interviews, and then conducted the second teacher interview. The students and the teacher referred to the actual portfolios during the interview.

The NCTM Goals Portfolio II was due on January 8, 1996. The written guideline for this portfolio was the same as that for the NCTM Goals Portfolio I except for an additional sheet titled "Semester Portfolio Reminders" (See Appendix C for this sheet.) that added two requirements to the portfolio. Students were to write a personal description of themselves and to decorate the folder for their portfolio. The teacher collected and reviewed the portfolios, after which the researcher reviewed the

portfolios, and then the researcher interviewed both the students and the teacher. The students and the teacher referred to the portfolios during the third interview.

Additional Portfolio-Related Documents

Additional written portfolio-related documents that were collected by the researcher included: (a) a class syllabus with portfolios listed as a component of the class, (b) teacher's grading plan, (c) guidelines for compiling the portfolio, (d) several journal entries assigned by the teacher relative to portfolios, (e) student selections and justifications for the Best Piece Portfolio, (f) comments written by the teacher to each student relative to their portfolio selections, and (g) a handout prepared by the teacher for a presentation she did at a state convention for mathematics teachers. These documents were analyzed in light of the other data collected in the study. For example, the teacher gave each student a sheet of written comments about their NCTM Goals Portfolio I. The researcher examined these comments and discovered that one of them directly influenced one student's portfolio selection. The researcher also asked the focus students, in the final interview, about their use of the teacher's comments.

The Researcher

This study employed a variety of data collection strategies which included interviews, observations, documents, written student work, and questionnaires. However, the key to all data collection and analysis was the researcher. There is always the potential for the personal biases of the researcher to influence the findings in a qualitative study. However, that threat may not be as great as it might initially appear, as is pointed out by Bogdan and Biklen (1982):

What qualitative researchers attempt to do, however, is to objectively study the subjective states of their subjects. While the idea that researchers can transcend some of their own biases may be difficult to accept at the beginning, the methods that researchers use aid this process. (Bogdan & Biklen, 1982, p. 42)

Bogdan and Biklen also noted that most biases and opinions are "superficial" and that if the data contradicts a researcher's ideas, the researcher will have a difficult time ignoring the evidence that was collected by the intensive methods used by most qualitative researchers. However, Bogdan and Biklen emphasized "Qualitative researchers try to acknowledge and take into account their own biases as a method of dealing with them" (1982, p. 43). Therefore, this researcher will relate prior experiences that may be potential sources of personal bias.

The researcher became interested in the use of portfolio assessment as the result of a combination of experiences which include ten years of teaching experience in the public schools and at the university level and participation in several innovative programs. All of these experiences have influenced her beliefs about teaching, learning, and assessment. One of these programs occurred during the summers of 1986 and 1988. This program was an innovative project funded by the National Science Foundation with the purposes of (a) training mathematics teachers of grades K-8 in new methods of instruction; (b) providing teachers with information on new topics such as problem solving, use of manipulatives, probability, statistics, hands-on geometry; and (c) providing teachers with information about the new philosophy of mathematics education that was soon to be published by the NCTM as the Curriculum and Evaluation Standards for School Mathematics. In the summer of 1987, the researcher participated in a intensive two-week workshop for teachers sponsored by the National Aeronautics and Space Administration (NASA) which emphasized real-life applications and the integration of mathematics and science. Finally, the researcher was a writer and later a research assistant for the SIMMS Project described earlier.

To neutralize researcher bias, the researcher kept a journal during the research study. Contained in the journal were detailed accounts of thoughts, ideas, and feelings experienced during the study as well as decisions that were made. This journal was used to help prevent bias when analyzing the data. For example, the researcher would reread the entries and attempt to determine whether opinions about the teacher's behavior were affecting the researcher's analysis of other data. The researcher made entries in the journal on the average of four times per week and also had a small notebook where she jotted down, even more regularly, any ideas of themes or avenues to explore. The journal became a valuable resource for the researcher in recalling the sequence of events and in clarifying thoughts about the research findings. The researcher identified with the findings Powell and Lopez (1989) reported in Chapter 1 where students reported that journal writing promoted critical thinking. This excerpt directly from the researcher's journal illustrates the critical thinking that occurred.

I have been reading Paulson & Paulson Assessing Portfolios Using the Constructivist Paradigm. It has made me think about some things going on with Julie [pseudonym given to the teacher] and the students. It fits with the idea I had earlier that students are constructing their own meanings about each of the NCTM goals.

- "Part of the learning for the student was to interpret the goal and to make it operational" (p. 6). Here I have found that the students define the five goals differently, and even differently from Julie. But that would be OK since they are constructing their own meaning of each goal. One thing to note and find out more about: it seems that Julie never discusses the NCTM goals or meanings with the students. It also seems that she does not interfere with the portfolios at all.

Journal writing helped the researcher to focus further data collection and to identify and explore emerging themes from the interviews, observations, and written documents.

Data Analysis

For data analysis the researcher used the method of constant comparison as described by Glaser (1978):

1. Begin collecting data.
2. Look for key issues, recurrent events, or activities in the data that become categories of focus.
3. Collect data that provide many incidents of the categories of focus with an eye to seeing the diversity of the dimensions under the categories.
4. Write about the categories you are exploring, attempting to describe and account for all the incidents you have in your data while continually searching for new incidents.
5. Work with the data and emerging model to discover basic social processes and relationships.
6. Engage in sampling, coding, and writing as the analysis focuses on the core categories. (Glaser, 1978, as cited in Bogdan & Biklen, 1982, p. 70)

The excerpt from the researcher's journal given in the last section illustrated the researcher's use of writing to explore the teacher's concept of the portfolio. After writing this excerpt, the researcher further explored the idea of whether students were being allowed to construct their own meanings of the NCTM student goals. It was determined from the second student interviews that the students did not discuss their definitions of the NCTM student goals with others and that the teacher did not give them definitions for these goals.

During the first phase of the study, the researcher immediately analyzed the student responses to the NCTM Goals Questionnaire. Student interviews were used to clarify responses on that questionnaire. Also, the researcher investigated how teacher interview responses corresponded to student interview responses on similar questions.

Student work, from the portfolios and other documents, was examined to further understand how the NCTM student goals were interpreted by the students.

During phases two and three the researcher compared and contrasted interview responses and observation data looking for themes or patterns in the data. The NCTM Goals Portfolios (I & II) were analyzed immediately upon collection to formulate interview questions for the students and teachers. During phase four, the questionnaire responses were compared to portfolios, interviews, and observations from the entire semester of the study.

The researcher conducted an ongoing literature review, as suggested by Glesne and Peshkin (1992). This can also be seen in the research journal excerpt that was given where the researcher wrote about reading an article that she found after the study had begun. In a study such as the one reported here, that focused on the perceptions of students, it was impossible to anticipate in advance the path the data might lead.

CHAPTER 3 ANALYSIS OF DATA AND FINDINGS

Introduction

The research question for this study was: What are high school mathematics students' perceptions about portfolios as a tool for assessment, that is, for demonstrating their progress in fulfilling mathematics goals? Those goals, identified by the NCTM (1989) as goals students should meet in any school mathematics program, are: (a) students learn to value mathematics, (b) students become confident in their mathematical ability, (c) students become mathematical problem solvers, (d) students learn to communicate mathematically, and (e) students learn to reason mathematically.

The chapter begins with background information that is essential to understanding the results of the research reported here. The background information includes a description of the classroom in which the study was conducted and descriptions of the students' portfolios. Next, profiles of the teacher and of the students are presented. Although the study focused upon the students, the teacher's perceptions and actions influenced the final results making it necessary to examine what occurred during the semester from her perspective. The last five sections of this chapter are based on discoveries that were made by examining the profiles in light of the portfolio implementation in this classroom. The results that were ascertained relative to the research question are presented in the first two sections following the profiles: (a) interpretations of the NCTM student goals and (b) perceptions of the use of the portfolios to demonstrate the NCTM goals. However, this study uncovered broader findings than just those that sought to answer the research question. The final three sections of this chapter focus on the unanticipated findings: (a) students'

perceptions of the portfolios, (b) students' recommendations to the mathematics curriculum committee, and (c) portfolio implementation issues.

Background Information

Description of the Classroom

At the beginning of the study, nine students were enrolled in this SIMMS Level 5 classroom, eight females and one male. About one month into the semester, one female student dropped out of school for health reasons and, at the end of October, a male student joined the class. As a result, there were two male and seven female students at the end of the semester. The pseudonyms for the students who participated in this study, excluding the female who left the class, are: Scott, Kristin, Mandy, Micheal, Cindy, Becky, Jennie, Carol, and Kathy. The first three listed are the focus students. A student from the previous year is referred to as John. The pseudonym for the teacher is Julie Olsen.

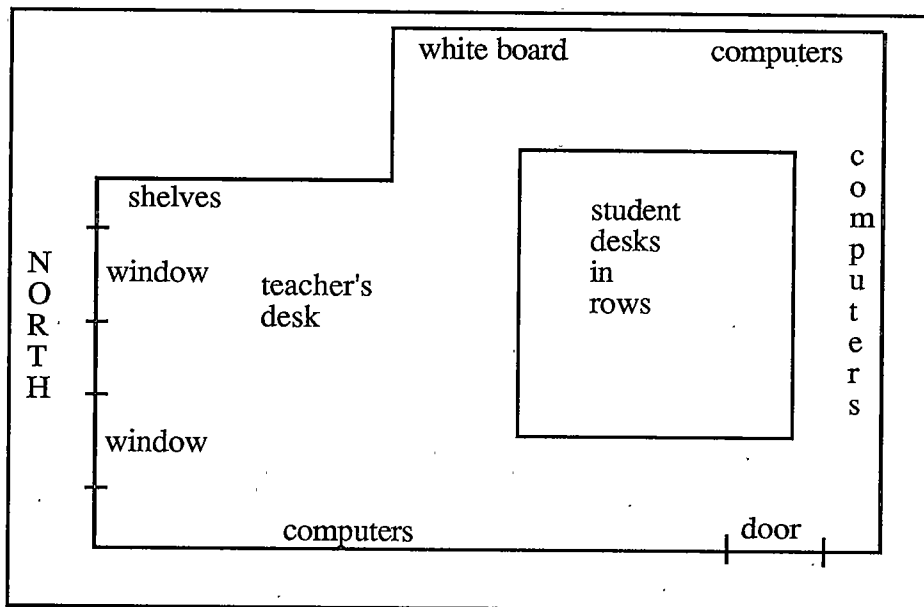
Seven of the students had participated in SIMMS mathematics at this school for two or more years. Recall, that this was the only SIMMS mathematics class in the school. At the beginning of the study, the teacher related to the researcher that she was sure these seven students would not be taking mathematics during their senior year if there had not been a SIMMS class. In an interview, the teacher also made this remark about her students.

A lot of them are the kind of kids that when the bell rings at 3:30, they're out the door and in school no longer, you know. . . . These kids have a lot of other things going on in their lives.

The mathematics classroom was quite spacious with desks in rows at the center of the room and computers on moveable carts around the perimeter of the room. Two large windows on the north side of the room afforded quite a spectacular view of the

mountain range located to the north of this small ranching community. There were 30 desks in the room which was considerably more than in previous years because a greater number of tenth graders were currently enrolled in the high school and also used this room.

Figure 3: Diagram of the classroom.



The furnishings, the carpeted floor, and the large window gave the room a casual, comfortable feeling. When the class was in session, the researcher perceived the atmosphere as open and non-threatening.

The students used graphing calculators freely and the teacher occasionally used an overhead projector equipped with an overhead graphing calculator. All of the students either owned their own calculators or had access to a school issue taking it with them after class. There was a large white board on one wall of the classroom where the student desks generally faced when they were working in rows. Students moved their desks together when they worked in groups.

A variety of classroom formats and instructional methods were observed. At times, the students worked at their own desks in rows and the teacher lectured. The teacher conveyed this about her classroom,

I have to say a lot of time they are [working in groups]. I still do whole class, like a traditional [classroom]. . . . Tomorrow when I go over those discussion questions, they've done them now as homework, but they didn't really get to talk together about them in a group, we'll go over those and that will seem very traditional. We'll go through that and I've got some things I want to make sure they understand before we move on. But then when I give the homework assignment, they'll be back in their groups again.

The following excerpt, taken directly from the researcher's observation notes, verified the teacher's description of what she called a "traditional" format in her classroom:

Teacher says, "Start with 2.4." She does 2.4 on the overhead. Teacher asks if anyone got it. Gives no wait time and picks Jennie. Then teacher tells Jennie how she [the teacher] did it. Teacher notes that she doesn't know what they want [referring to the authors of the module]. Teacher asks Jennie for the identity matrix. Jennie says nothing and so the teacher goes right on and tells them what matrices to multiply and asks them what they get. Students are busily entering matrices into their calculators. Teacher tells them how reflections can be modeled with matrices. Very little class participation. Students are attentive. Teacher asks, "Why is this important?" and then answers her own question. Composing transformations makes it easier for computers she tells them.

Other formats were also observed. Students moved their desks together and worked in groups on homework problems or explorations in the modules. Explorations are sections in the SIMMS modules where students work in groups, following a prescribed procedure, to make a discovery. During one class period, the students spent most of their time performing an experiment. They measured the pH of various solutions and then recorded changes in pH as a basic solution was added to an acidic solution. One student recorded data on the white board while two students conducted the experiment. The following excerpt, taken directly from the researcher's observation notes on November 30, described one scene from that class period.

She [the teacher] made a chart on the board. They will do a class experiment. Scott and Micheal use the probe and do the drops. Carol will record on board. Students have to record data on paper because they now need to put it on a spreadsheet. Micheal has the kids laughing. "Wanna be in our band Scott? You can play the beaker. You're the best beaker player I know." He [Scott] is stirring baking soda into pop. Teacher says, "One thing I'll tell you here. PH_2O means you haven't added anything."

That day much joking occurred and laughter permeated the classroom. The researcher noted that the students discussed their findings much more freely than was usual. After the students finished gathering data from the experiment, they proceeded to the computers and entered the data into a spreadsheet.

Alternative mathematics assessments were employed by the teacher. Several times the researcher noted that students were directed to write in their journals at the beginning of the class period. Two entries, assigned on different days, were: (a) "What 'new' mathematics have you learned [referring to the module they were using]? Do you think this math is useful? Why or why not?" and (b) "Explain why you think sine and cosine are called circular functions. Why are they used to model cyclic phenomenon?" The teacher also assigned journal questions relating to portfolios and shared the students' responses with the researcher. In addition to journals, of course, portfolios were utilized.

Descriptions of the Portfolios and Portfolio Events

The students in this study compiled two different types of portfolios. The first type was the teacher-directed portfolio, referred to as the "Best Piece Portfolio," and the second type is referred to as the "NCTM Goals Portfolio." The NCTM Goals Portfolio was collected twice, once at the middle of the first semester (NCTM Goals Portfolio I) and once near the end of the first semester (NCTM Goals Portfolio II). The

researcher differentiated between the NCTM Goals Portfolio I and the NCTM Goals Portfolio II, but the teacher preferred to think of the NCTM Goals Portfolio I as a rough draft of the NCTM Goals Portfolio II, feeling this would help the students to perceive the portfolio as a process. The following section describes the two types of portfolios and discusses the events relative to these portfolios.

The Best Piece Portfolio. Four times during the semester of this research study, the teacher had the students select "best" pieces of work for the Best Piece Portfolio. Upon completion of a module, the students were tested. After the test was graded and returned, they looked through all their work from that module and selected one piece of work. They wrote a justification of their selection answering these two questions: "1. Explain why this piece is the BEST!!!! Use complete sentences!!!! 2. What was the criteria you used to pick the best piece of work? Use complete sentences!!!!" This selected piece of work was placed in the Best Piece Portfolio and selections were never changed nor were justifications edited. The teacher also selected items to be included that were the same for each student. Those items included open-ended problems the students had completed and selected journal writings. Any pieces of work from the Best Piece Portfolio could also be used as selections for the NCTM Goals Portfolios.

During the semester of this study, the teacher never discussed this portfolio or the process used to compile it with the students. When the researcher asked her about this lack of discussion, she said that most of the students were familiar with the portfolio from the year before and did not need any further assistance. However, not all of the students did have previous experience with portfolios. Also, the selection and justification were assigned as homework to be completed out of class. Therefore, the researcher observed nothing about the process of compiling the Best Piece Portfolio.

The only time that the researcher saw this portfolio, during site visits, was when the teacher handed the students their Best Piece Portfolios the week before the NCTM Goals Portfolio II was due. At that time the teacher told the students that they were to make selections from this portfolio for use in their NCTM Goals Portfolio.

There were some similarities in the types of portfolio selections in the Best Piece Portfolio. Tests comprised more than half of the selections. One student selected tests from all four of the modules and all students selected the test from the Motion Pixels module. The teacher's theory on the high percentage of tests selected was that the modules this year were much more difficult than the year before and that the students finally understood the module by the time of the test. Seven items, or about 20% of the items, were review assignments. Review assignments would also provide evidence that the student finally understood the material and could also be explained by the teacher's theory of module difficulty. Other items selected were computer activities, explorations, and homework. Two students selected just one problem from a homework assignment.

Similarities were also noticed in students' justifications provided for portfolio selections. The justification for about 25% of the items was that the student received a good grade. The justification for another 25% of the items was that the piece gave evidence that the student understood the material. Other reasons for selection of items included: (a) the student was proud of the work, (b) the student had fun, (c) the student learned something new, (d) the selection demonstrated everything in the module, or (e) the content was interesting to the student.

The NCTM Goals Portfolios. The students did not work on the NCTM Goals Portfolios continuously throughout the semester. The teacher focused the students' attention on these portfolios twice during this study. Each time was just prior

to the due date. (See Appendix A for a table of dates, events, and amount of time spent on portfolios.) On September 6, 1995, the students were given their last year's portfolios and a sheet of questions asking them to reflect on that portfolio. (See Appendix C for the reflection sheet.) The end-of-year portfolios were very similar to the NCTM Goals Portfolios. As the teacher distributed these portfolios, she commented that they may not have seen their last year's portfolio grades. The portfolios were turned in very close to the last day of the school year and some students did not have time to come in and look at their portfolio after the teacher had graded them. Students who did not have a portfolio from last year were furnished with another student's portfolio to examine. The students were given 15 minutes to review the portfolio and respond to a sheet of questions (See Appendix C for the questions.). During that 15 minute time period, the students were also instructed to arrange some colored paper in their binders for journal entries. Students spent the majority of the 15 minutes arranging this paper for their journals. The students answered the questions about the portfolio independently and then the teacher collected the reflection sheets and portfolios. The teacher shared students' responses with the researcher. According to the teacher, the responses to the reflection sheet and the end-of-year portfolios were never discussed on any other day.

On October 24, the students were given the NCTM Portfolio guideline sheet (See Appendix C for the guideline.) with one minute remaining in the class period. The teacher said, "We will talk about these tomorrow." The teacher reported that they never had the opportunity to discuss the guideline until November 1. That day the students were given about 20 minutes at the end of the class period to work on the portfolios. Several students complained that the task was tedious. The teacher reported that no one asked any questions and the focus students verified this in their interviews. The students and teacher also reported no interaction or discussion among the students

during this work time. Most students finished their portfolios over the following weekend. The researcher had planned to be at the site on November 1, but severe weather caused cancellation of the visit.

The NCTM Goals Portfolio I was due on November 3, but the teacher administered a major test during two class periods resulting in postponement of the deadline. The portfolio was worth a completion grade of 50 points. A completion grade was an amount of points awarded for doing the task and appearing to put some effort into it. The teacher decided to add the portfolio score to the second quarter grade because of the postponement of the due date. On November 9, the researcher picked up the portfolios at the site, but two students had not turned theirs in. Two focus student interviews were conducted on November 15 and one had to be rescheduled for November 30 due to student-illness. One student never turned in the NCTM Goals Portfolio I and received 0 points and two of the remaining students received failing scores. The teacher was disappointed in the quality of the NCTM Goals Portfolio I and with the lack of effort that some of the students displayed. In the formal teacher interview on November 30, 1995, and in informal telephone interviews during the months of November and December, the teacher discussed with the researcher possible ways to encourage the students to do better work on the next portfolio.

In a phone conversation on December 15, the teacher told the researcher that she had contemplated having a portfolio work day on the Thursday before Christmas break, but later decided to administer a test. She planned to allot work time for the portfolios the first few days after Christmas break. On December 21, the teacher advised the researcher that she would be working on open-ended mathematics problems, journal entries, and the portfolios on January 2 through January 5. The students would be required to do an oral presentation on their completed portfolios instead of taking a

semester exam. The portfolio and presentation grade would replace the semester exam score.

The researcher visited the site each day from January 2 through January 5. On January 2, about 10 minutes were spent on portfolios. The teacher asked the students to write a reflection on the quality of the NCTM Goals Portfolio I. One of the questions was:

Your semester NCTM goals portfolio will count as a test grade (100%) this quarter. Your first draft was turned in at the end of the quarter and counted 50 points. Unfortunately, some students in the class put little or no effort into their portfolio. The ones that were completed at the end of the school year were outstanding. What is your theory on this?

Seven students responded to this question. The new student did not respond because he had not completed a portfolio and another student, who did not turn in the first portfolio, did not turn in her journal entry either. Four of the seven students said the questions were the same and that doing the portfolio was tedious or seemed like "busy work." The two students who had never prepared this type of portfolio before did not express feeling that the portfolio seemed tedious. Of the two students who had turned in but failed the first portfolio, one attributed it to his laziness and the other said she did not understand the instructions.

On January 3, 23 minutes were allocated to the portfolios, which consisted entirely of the teacher talking and displaying an example of student work that she said met her expectations. Also on that day, she handed each student a list of written comments suggesting ways they could improve their NCTM Goals Portfolio I for submitting it as the NCTM Goals Portfolio II. The teacher added two requirements for the NCTM Goals Portfolio II. Each student needed to decorate a colored folder demonstrating personal interests and to write a one page personal description. In addition, the students were to present the portfolio to the other students as a

replacement for their semester exam. On January 4, the teacher allotted 39 minutes for portfolio work. This time included the teacher giving directions for about 10 minutes, students working independently on portfolios for 24 minutes, and students visiting about the upcoming pep rally for about 5 minutes. On January 5, 52 minutes were allotted to the portfolios. Teacher directions accounted for about two minutes. Students worked and asked the teacher questions as needed for the remaining 50 minutes. The students asked a total of nineteen questions relating to the portfolios during the four days. The NCTM Goals Portfolio II was due at the beginning of the class period on January 8.

On January 11, the researcher picked up the portfolios at the site and the student and teacher interviews were conducted on January 12. The students presented their portfolios on January 17, with a portfolio and presentation grade replacing their semester exam score. The presentations lasted 25 minutes for an average of about 3 minutes per student. All of the students turned in their portfolios, although four were one or two days late and two were incomplete. One student received a failing score on the portfolio because it was late and incomplete. This student had received a 0 on the NCTM Goals Portfolio I because she had not turned it in. The teacher was pleased with the quality of the portfolios and the students' efforts in compiling the final NCTM Goals Portfolio.

The items selected for the NCTM Goals Portfolio II were so varied that patterns in their selections were not found. There were tests, journal writing selections, review worksheets, homework assignments, summaries of modules written by the students, class notes, computer print outs, and module explorations. The only unique item was selected by Kristin, a focus student. Her selection was a description of tutoring another student as a model of her mathematical communication skill. No piece of written work accompanied her justification. The students had been required to place in their

portfolios one selection for each of the five goals and two additional selections of their choice. The two extra selections also varied widely. A few examples of the reasons for selection of the extra items were that the item: (a) was fun to do, (b) showed the student's ability or understanding, (c) showed more than one of the goals, or (d) portrayed the student.

Summary of the Classroom and Portfolios

The class participating in this study consisted of only nine students. The majority of the students in the class, according to the teacher, were not the top mathematics students in the school. The mathematics curriculum used was innovative and integrated, with technology employed on a regular basis. A variety of instructional methods, including lecture, individual seat work, group work, and discovery, were utilized by the teacher. Alternative mathematics assessments, including journals and open-ended mathematics problems, were also used by the teacher.

Neither the Best Piece Portfolio nor the NCTM Goals Portfolio was worked on continuously throughout the semester. Selections for the Best Piece Portfolio were made at the end of each module, or about once a month, and selections for the NCTM Goals Portfolios were made twice during the semester. The contents of the two types of portfolios were different with tests comprising about half of the Best Piece Portfolio selections, but only about 10 percent of the NCTM Goals Portfolios.

Profiles of the Teacher and the Focus Students

The research reported here was an in-depth study of three focus students, but as the study progressed it became apparent that perceptions and actions of the teacher were playing a critical role in the way the students dealt with the portfolios. Because of the

teacher's influence, it is important to examine the portfolio experience from her perspective. The first profile in this section, then, will be the teacher's which will answer the following questions: (a) What were the teacher's previous experiences with portfolios? (b) What did the teacher hope to gain for her students and herself by implementing portfolios? (c) How did she perceive the experience of portfolio implementation and what strategies did she utilize to promote a quality experience for her students? and, finally, (d) Did she accomplish her goals and personally profit from the experience? The student profiles follow the teacher profile. The student profiles are chronological and include background information that paints a picture of each student by using written work and interview excerpts. Previous experience with alternative assessment, interpretations of the NCTM student goals, and experiences with the NCTM Goals Portfolios are also part of each profile. The profiles end with the students' final perceptions about the portfolio for demonstrating the NCTM goals and the personal benefits each student felt were derived from the portfolio experience.

As the reader examines the students' perceptions about the portfolio as an assessment tool for demonstrating their attainment of the NCTM student goals, it is important to be aware of the fact that the teacher did not discuss her interpretations or the NCTM's interpretations of the goals. Therefore, interpretations of each goal varied from student to student and, in some cases, students' interpretations were not as complete or accurate as those intended by the NCTM when they proposed these goals for mathematics.

Profile of the Teacher, Julie

Julie's Previous Portfolio Experiences. Julie had prior experience using mathematics portfolios, but only in one class, her SIMMS class. She had implemented the Best Piece Portfolio during the previous year (1994-95), allotting little

class time for students to work on selecting and justifying items. At the end of that year, she had experimented with a different type of portfolio. That portfolio was very similar to the NCTM Goals Portfolio used in this study. Students were instructed to select one piece of work to represent each of the mathematics standards for students listed in the Montana School Accreditation Standards and Procedures Manual (1994). These standards are identical to the NCTM student goals except for one additional standard: "In a basic mathematics program, students select and use appropriate technology to solve problems and acquire new knowledge" (p. 16). In the following excerpt, Julie and the researcher discuss the portfolio compiled at the end of the previous year.

Interviewer: Last year, I know that you usually had the students select their "best" piece of work, but then at the end of the year you tried something different. What made you decide to use the Montana Standards for a final portfolio last year?

Julie: Well, I think the idea that those . . . are the goals the state has said that you should have and that would be a way to see what the kids interpreted those goals through their work by finding their piece. I can see where that can be carried over when we [the school] do our assessment because how do you assess, you know, even communication.

"Our assessment" referred to the methods her school would use to assess their new mathematics curriculum standards.

During the 1994-95 school year, Julie had become a member of a committee formed to rewrite the school mathematics curriculum and to set standards to be assessed. The committee continued its work during the 1995-96 school year. She was implementing portfolios during the 1995-96 school year for the following reasons: (a) to have something to show to parents, (b) to have a method of documenting student growth, and (c) to provide her current students with the opportunity for self-assessment. But she also had an additional goal of testing the assessment method for a

more encompassing purpose, that is, to test portfolios for use with the district's new mathematics curriculum. In an interview, Julie discussed her work with the mathematics curriculum committee.

Interviewer: Please tell me about the math curriculum meetings you had last spring, in particular, what was the discussion about assessing the Montana Accreditation Standards of valuing, confidence, problem solving, communication, and reasoning?

Julie: We just had a meeting last week about this. We have written our curriculum and it is fairly based on the NCTM Standards. It's almost quote. Then we do have to write assessment for that. . . . We want it [our assessment] to be real broad and then we want to use the assessment not to evaluate teachers, but to evaluate the curriculum to decide whether that goal does not belong where we have it or maybe that should be a goal or shouldn't be a goal. . . . They want to evaluate the curriculum itself.

She also described her plan for using portfolios school wide.

Interviewer: How are you going to try to assess those standards like valuing, confidence, problem solving?

Julie: Well, we have those in our philosophy statement and they are in our goals and so we haven't got to that discussion. . . . But we decided . . . we aren't going to be able to test those things using traditional assessment. That's as far as we got with that. And that is where my suggestion is going to be to do a four-year portfolio. And then I think that we can get a little bit of confidence and valuing out of the kids by doing something like that where they will write like we've done [referring to her use of portfolios]. But that, it might not fly. It's going to be my suggestion.

The mathematics committee had decided that certain goals of the new curriculum could not be assessed by methods they had used in the past, but a final decision had not been made about the types of new assessments that would be implemented.

Julie's Interpretations of the NCTM Student Goals. During the first interview, the researcher asked Julie to define the NCTM student goals. She exclaimed at several points in the interview, "Is this supposed to be easy?" It is important to

understand how she interpreted these goals because she eventually attempted to grade whether students demonstrated their attainment of these goals in their portfolios. Also, she decided to allow the students to interpret the goals themselves and, except for one instance during the semester, she did not share her interpretations or the NCTM's interpretations of these goals with them. Her definitions, conferred during the interview, follow. (For a complete description of each goal, as given by the NCTM [1989], see pages 4–5.)

Valuing:

For me to value it, it does have to have some kind of meaning or use. . . . It could be used in my life and I might value it. . . . If they [students] value it, . . . they don't care so much for the grade. They really want to know it because they know they are going to need it in the future.

Confidence

I think if you are confident in your ability, you'll just plunge right into things. I think . . . you're a risk taker. . . . They'll [students will] take a hard problem and not leave it blank. They [students] have confidence in their ability to do mathematics and so maybe it is wrong, but "This is the way I interpret the problem, so this is the way I am going to answer it," and not come up and ask me.

Mathematical Problem Solving

To me being a mathematical problem solver is being one that can take mathematical problems and try various approaches and strategies and come to a solution that they [students] feel good about and can justify and say "I think this answer is correct because (trails off)."

Mathematical Communication

Communicating mathematically, to me, is when you are using your graphs and diagrams and your equations that you used in your solutions and you can also have written work. . . . You are using the language of mathematics. . . . [The students don't think] that you can communicate through the symbols of mathematics. . . . They just think written words or oral words, . . . an explanation of what they did is what they'll pick out.

Mathematical reasoning

[Reasoning is] that ability to logically think and reason through things. . . . I really view reasoning mathematically as thinking mathematically in a real logical way. . . . I think you can pick up a paper and read it and say they can reason mathematically because you can follow their logic, [but] maybe that is more communication."

In an informal discussion with the researcher, Julie discussed whether mathematical reasoning could be taught. During the course of the discussion she decided that it probably could, but that she was not consciously aware of teaching it.

Julie's Dilemmas. Before the end of the first quarter, Julie was discussing problems with the portfolios on a weekly basis during the informal telephone interviews. She was concerned that the students would not have had time, by the end of the first nine weeks, to collect enough material from which to make selections for their NCTM Goals Portfolio I. She allowed for the lack of material by giving this option in a written guideline for the NCTM Goals Portfolio I: "If by the end of the first quarter, you cannot find an item that is satisfactory, you will write and tell me what kind of item you would like to put in the portfolio and why." She emphasized to the students that the NCTM Goals Portfolio I was a rough draft of the NCTM Goals Portfolio II due at the end of the semester. She informed them she would give them a grade for submitting their rough draft, the NCTM Goals Portfolio I, and showing effort in compiling it. This type of grade she referred to as a "completion grade."

The first NCTM Goals Portfolios, turned in at mid-semester, did not meet Julie's expectations. When the researcher asked for her general impressions of the portfolios, she said, "I wasn't real happy with them. . . . I didn't think that there was a lot of effort. They were pretty incomplete." She was not disappointed in Kristin's or Mandy's portfolio, but she was in Scott's and some of the other students in the class. Her theory on Scott's performance was that he was tired of answering questions about the NCTM student goals and he verified that in his interview: "The same questions [referring to the student goals], answering the same questions periodically is kind of stressful."

In the second formal interview, additional problems with the portfolios surfaced. The interview seemed to be a forum for Julie to reflect on the problems and to brainstorm ways to make the portfolios a success.

I don't know how much of that [the poor quality of the portfolios] is the kids' fault, because I do think the fact that they only had two modules to pick from [was a problem]. I think that it was a chore for them because they did not have enough work to pick from. . . . And they might, too, have misunderstood my thing about "If you don't have something it's OK, but you have to write and tell what you would put in there." I was getting blank sheets of paper and nothing written. I think that they just misinterpreted that. The next time, like for the semester one, I want to give more [direction], and I thought, I counted this 50 points, that's a lot of points. But I still have one that is not turned in, so I think I want to make more clear how I am going to grade next time on their presentation, however I decide to do it. How I am going to grade, and hopefully, make sure they think that it is important enough to spend some time on. But like I said, I think there are a lot of factors. I think because they have done it before, it's a kind of busy work, and they're the kind of kids that grades to all of them are not important enough to do this. They'll just take a 0. That's what some of them are like.

Her dilemmas, from this excerpt and from other segments of the interview, included:

(a) students did not have enough work products to select from, (b) students did not have enough variety of materials to select from, (c) some students misinterpreted the directions, (d) some students may have misunderstood the grading procedure, (e) some students were not making a serious effort to compile the portfolio because they were tired of the NCTM student goals, (f) there was not enough time to communicate with the students about their portfolios, and (g) she was not sure how to use grades to encourage the students to complete their portfolios.

Julie's Strategies to Improve the Students' Portfolios. Julie employed several strategies to help the students improve the quality of their NCTM Goals Portfolio II. She implemented her plan during the first week of January, one week before the portfolio was due. First, she had the students reflect upon the quality of the NCTM Goals Portfolio I. (See Appendix C for this reflection sheet.) She also

had them work on open-ended mathematics problems to give them more variety for their selections. (See Appendix C for the Grasshopper, Drug, and Salary problems.) To encourage the students to assume ownership of the portfolios, she added two requirements for this second portfolio. The students were instructed to decorate a portfolio folder depicting their personality and to include a written description of themselves. The handout with additional requirements is contained in the Appendix. To combat problems of misunderstanding the directions, Julie spent time in class discussing the portfolio directions and showed the students an example of a student selection and justification that met her expectations. She also gave the students written feedback for improvement based upon their NCTM Goals Portfolio I. The students were given almost 90 minutes of class time to work on their own portfolios. Her final strategy was replacing the semester exam with the portfolio and a presentation of the portfolio to the class.

After the second NCTM Goals Portfolios were submitted, the researcher asked Julie, "Were you satisfied with the final portfolios?" Her response was:

I was. I think everything can be improved, but I felt that they put more effort into them. Some were missing some parts, but that happens with any assignment. I gave them a handout. It had a list of things to do. Kids do that and they are going to pay for it in their grade, but I was pretty pleased. I felt that they came through for the most part on what I asked them to do.

Julie adjusted her plans to make developing portfolios a more worthwhile experience for the students and, in her opinion, the strategies had been successful.

Julie's Goals for the Students. At the beginning of the semester, Julie informed the researcher that she wanted the portfolios to satisfy several goals for her students. Her goals were not totally fulfilled as seen in the following interview excerpt.

Interviewer: Did using the portfolios, either kind that you did, fulfill your goals for students which were to have something to show parents, to

provide a place to show growth, and to provide the students the opportunity for self-assessment?

Julie: They've really been great, I think, for the self-assessment because I still feel that when those students were going through and picking their work, they were having to look at their work and think about how they did it and whether it was good or not. The showing growth - I think I'd have to compare them [to the portfolios last year]. I've seen growth but, like from the beginning to the end of the year, I think it's easier to look at the portfolios they did last year. . . . And then showing parents - I haven't shown parents. . . . I have shown the principal, though, and different things from the portfolio as they come up and there's been a lot of things that have been real impressive.

Although all of her goals for students had not been fulfilled, she felt the portfolios had fulfilled the goal of self-assessment, which she had identified as her most important goal at the beginning of the study.

Julie had also wanted to test the portfolio for helping her school evaluate their new mathematics curriculum. The portfolio, in her opinion, would be worthwhile for her school.

Interviewer: Did using the portfolios help you to decide whether they [portfolios] will help your school in evaluating your curriculum?

Julie: Definitely. . . . Assessment is so hard and we've got all our curriculum and we feel really good about it and everything. Assessment is next on our list and I really don't think this is that hard to do. It's just a matter of having a file somewhere and having the kids organize them at the end. Then you have some really neat product that you can use. . . . I think it would be a really neat way to evaluate the things like valuing and I think, too, we might have something we want to put in there for problem solving that will be kind of standardized, . . . a problem like that blood problem [Drug Problem - see Appendix C]. . . . And we have technology as one of our goals and maybe we want something where they have to find appropriate technology to do it. . . . I don't think you can evaluate problem solving that easily on a standardized test, or reasoning. . . . So I think there is a real good chance we will look at some of this for our curriculum.

Julie's Final Perceptions of the Portfolios. In the final interview, Julie was asked to evaluate the portfolios in terms of demonstrating the students' attainment of each of the NCTM student goals. She appeared to be certain of only one of the goals, mathematical problem solving. However, she noted that she gained information about students' thinking by examining their portfolios.

Julie was undecided when asked, "Have you found that the portfolios are a good method for helping you to assess your students' valuing of mathematics?"

In some of their writing, they made statements like: "I wouldn't have taken this class if I didn't value math." [or] "I like this math because I can use it and I value things I can use." Which I thought was a real key to why mathematics has been so hard in the past because they say if you don't value something, do you really learn it? I think I would not have gotten that information without them struggling with ways to explain what valuing was. . . . So I think it is hard for those kids to show valuing themselves, but through their struggles it has shown me what they view valuing as. As far as a teacher goes, I've learned more about how they value math than maybe they are able to show. It's hard to explain. . . . Also, the question [the student justification of the selection] itself that is in the portfolio and their struggles with "what is valuing" is giving me the information. You are really seeing what the kids think valuing mathematics means to them. Valuing something, what does that mean?

She was not sure that the students could just select one item to demonstrate valuing of mathematics, but she did gain information about the students through their attempts to demonstrate how they valued mathematics. The NCTM Assessment Standards (1995) stated that assessment is "the process of gathering evidence about a student's knowledge of, ability to use, and dispositions toward, mathematics" (p. 3). From examining the portfolios, Julie gained information about her students that she may not have been able to gain in any other way.

Julie was hesitant about the portfolio as a good method for showing students' confidence in their ability to do mathematics and she was not able to offer any quick solutions, either, to assessing this attribute in students.

Julie: That is probably one of the harder ones to show. Again, I think I gained information, though, about how the kids . . . view

themselves as being confident. . . . I think confidence is something from within, . . . like I am real confident when I take tests. I have always been a good test taker. . . . I got an impression of what their view of their own confidence was, whether they had it or not. But I don't know whether you can show someone your confidence by showing them a piece of work. I got a really good impression [from the portfolio] of Scott. [He] is very confident, very, very confident.

Interviewer: Yes, he said that he didn't do well on his PSAT [standardized test], but then said, "I am good at math."

Julie: And he is and he knows that. . . . He realizes, too, that a test doesn't tell you that much either. And see, he is one I call confident and he knows it and you get it from reading the way he writes things. And you also see it in his work.

She felt that she could recognize confidence by examining students' work and writing in their portfolio, but she also felt that showing it with just one item was not always possible.

Julie was more certain about the use of portfolios to demonstrate the mathematical problem solving ability of students than she had been about valuing or confidence.

I think portfolios are a really good way to look at problem solving, . . . like where you give them problems, like maybe . . . those problems I gave them [referring to the Drug Problem, the Grasshopper Problem, and the Salary Problem - see Appendix C]. They were really poorly done, but that did tell me that they are weak and they still are not thinking through these things the way they need to. So it gave me information again.

She felt the portfolio was valuable for showing the students' problem solving skills, or lack of them. Notice, however, that she gained this information about problem solving ability by looking at open-ended mathematics problems that she had assigned. She was focusing upon those problems, not on the portfolio as a whole, for documenting mathematical problem solving ability.

In the interview, Julie did not answer the question about the portfolio as a method for demonstrating skill in mathematical communication until after she expressed

her concerns about the students' definitions. She was still concerned, as she had been during the first interview in the fall, that some students had a different definition of mathematical communication than she had or than she thought the NCTM had given in the Curriculum Standards (1989). However, recall that she chose not to discuss the meaning of the goals with the students during this semester.

Interviewer: How do portfolios work for showing mathematical communication?

Julie: (long pause) That's the one area where I still don't think the kids view the same as I do. . . . Almost all of them view mathematical communication as oral or written. . . . I don't know if that goal when it was written [in the Curriculum Standards] - I get the impression that it is through, diagrams, and symbols and sketches and that is not the way kids view it, but that is good to know. But that is one thing that I noticed from reading theirs [definitions of the goal].

She finally gave her opinion on the portfolio, but continued a discussion of her concerns.

I think you can get that information maybe if you ask kids to put certain pieces of work in. That was one area where you can't mark them wrong for it, but this is how they show you that they communicate mathematically by talking. . . . Being able to talk about a problem is really important, but I don't think they are viewing it the way the goal was written for the NCTM Standards, so their pieces are not reflecting what the NCTM Standards are saying they want kids to be able to do. They are coming up with their own view of it.

Julie thought she should select items for the students to place in their portfolios to display their communication skill, because the students had different definitions than the authors of the NCTM Curriculum Standards. However, she did not appear to be bothered by students' definitions of the other goals differing from the intent of NCTM.

Julie's reaction to the question about the success of the portfolios in demonstrating mathematical reasoning was very strong. She was certain the portfolios had not succeeded in this area and she had no suggestion about what would work or whether this ability could be tested or assessed in any way.

Interviewer: How does the portfolio do in showing mathematical reasoning?

Julie: Oh God. Ohhhh. I don't think it did it on that one. But how, hmmm, it's weird because, like the SAT's, it's called the reasoning test. I am thinking they claim they are checking your reasoning by giving you these certain problems and I think . . . what exactly are they [doing] (laughs). I don't know. That is my hardest one. That and valuing are hard for me. But reasoning is really hard . . . and I don't know how, truly, people test someone. I think they give those standardized tests and if they get so many right then they must be good reasoners and we are going to say they are good.

Julie had no easy solution for assessing mathematical reasoning.

Despite the difficulties she encountered while implementing the portfolios and the poor results with the NCTM Goals Portfolio I, Julie was very positive about the use of the portfolios. When asked whether she would utilize them again, even if her committee chose not to use them for the school curriculum, she said,

Yeah, I think I will . . . for my next year in my other classes, because this is the only class I've been doing anything with portfolios. . . . But I was kind of thinking about what I could do with . . . portfolios especially where next year we want to get away from the traditional geometry and do more SIMMS. . . . Now I grade notebooks. I'd do this instead because I think that this is just a little more valuable for the kids and notebooks are more organization. That's all they are. And I think they [notebooks] are valuable, you need to be organized, but this [portfolios] I think would give us more information.

Although Julie felt that portfolios may not have been an exceptional method for demonstrating the students' attainment of the NCTM goals, their use had provided an extra benefit she had not anticipated. Using portfolios had given her real insight into her students as individuals. "I think I learn more about them as people. How they think and feel. What they have liked and disliked about the math, which I think is real important to know."

Profile of the Focus Student, Scott

Scott's History and Experiences with Mathematics. Scott wrote the following about himself and his future plans.

After high school, I plan to go into the Navy where I will do one of three things; a pilot, a mechanic, or a Navy Seal. Once out of the Navy, if I don't make it a career, I want to have a job that allows me time to spend outdoors and with my family. I plan to retire in either Montana or Idaho. After that, well I guess I'll just see where I go from there.

I like to think that I'm outgoing and energetic with a bit of a dangerous side. I love to hunt, ski, fish, play sports, hang out with my friends, and ride horses, especially in the mountains. My hobbies are woodworking, mechanics, and pretty much anything that's outdoors. I spent a lot of my free time outdoors doing whatever I can sometimes no matter what the weather is like. Ranchwork, playing in the snow, swimming in the rivers and lakes of Montana, and camping whenever I get the chance.

These statements were part of an autobiography that Scott wrote to include in his NCTM Goals Portfolio II. The teacher had added the personal description to the requirements for that portfolio.

At the beginning of his eleventh grade year Scott wrote the following response to this question: "Write an autobiographical sketch of yourself as a math student. Include your strengths and weaknesses, your likes and dislikes. What do you remember about your successes or failures?"

As far as I can remember math back in grade school, I've always been good at it [math]. Since first grade, adding and subtracting [subtracting] small numbers. Then later we learned how to divide and multiply. I understood math completely through grade school. But when I reached 7th grade I had some difficulty. It was mostly fractions and decimals. I always have never fully understood fractions and still don't. My 8th grade year wasn't very difficult but not very easy either. My freshman year math was fun. I had a fun math teacher in California. She made it fun. Last year my sophomore [sophomore] year I was introduced to a new kind of math, SIMMS. I [it] was different. It wasn't a lot of straight problems out of a book. It had a variety of things to learn and comprehend. I like it. Even though there were a few times I didn't completely understand. I'm doing SIMMS this year also. I hope it will be as much fun as last year.

During the year of the research study reported here, Scott was a senior in high school. He was not one of the original 16 students in this school who began in integrated (SIMMS) mathematics during their ninth grade year. He had joined the class during his tenth grade year. Therefore, the year of this study was his third year in SIMMS mathematics. He was the only student, of the three focus students, who had worked on portfolios for an entire year before his senior year. At the end of his eleventh grade year, Scott had reflected upon the use of portfolios.

Using a portfolio this year and last year is really helpful. It helps in a couple of ways. One is that it lets me look through all of my work from that module and lets me use my own judgement [judgment] on how well I did. It also lets me decide which piece of work I did the best on. Another way it helps is that anyone else that looks at it will see the best piece for that module, and not the mistakes I might have made on other work. The benefits of using a portfolio are that it keeps a record of improvement and talent. It makes it so teachers and other supervisors can judge the talent or ability. The drawbacks of doing a portfolio is [are] that sometimes when picking the piece, it is hard to say in words what I want to say about it. I see the portfolios as a way for teachers and supervisors to analyze and interpret students [student's] work over every field that is covered.

The portfolio that Scott referred to contained the "best" piece from each module completed during that school year. This was the same type of portfolio that the teacher continued during the semester of the research study, the Best Piece Portfolio.

During Scott's eleventh grade year, the researcher got to know him through his writing, which was generally lengthy and descriptive, and by observing him from the back of the classroom during site visits. The day the researcher formally met Scott was on the day of the first interview. He was wearing jeans and a t-shirt and his brown hair was cut fairly short in a style typical of most male students in this school. Scott and the researcher talked for a few minutes about his plans for the future. The researcher asked him whether she could interview him later in the year and he said it would have to be this semester, because he was going to take advanced P. E. (physical

education) next semester. She had already known this because he had written about it the previous spring.

Just another example of how important math is to me, next year Integrated IV is being offered only 7th period, but I wanted to take a full year of P. E. so I thought about it and decided to only take a semester of P. E. and take a semester of math.

Scott was presently torn between the value of mathematics and the value of P. E. He informed the researcher that, upon graduation, he intended to enlist in the military or in ROTC while attending college. He did not seem very confident about being accepted into ROTC or college. However, he did exhibit self confidence in his mathematical ability in some of his interview statements: "I think I'm pretty good at problem solving. . . . I think its natural. . . . I think math runs in the family. . . . I admit that sometimes I am lazy, but I enjoy math and I catch on quick." He also did not allow standardized test scores to interfere with his confidence.

When I take my SATs I don't show up good, but I'm taking a different math than everybody else. . . . I've been taking the SIMMS for 3 or 4 years so I'm learning a different math from everybody else. 'Cuz the geometry and the trig and stuff is standard for school and this SIMMS is new and I'm learning different stuff from everybody else and so they're getting standard questions. So on my tests, . . . like my ASVAB [a test used to qualify for military service], it showed that I wasn't good at math when I know I am - when I'm working with this different math.

Scott's Interpretations of the NCTM Student Goals. Recall that

Scott's teacher did not discuss her interpretations or the NCTM interpretations of the student goals with the students during the semester of this study. Therefore, interpretations of each goal varied from student to student. However, some students did alter or expand their definitions during the semester. Most of Scott's definitions remained fairly stable from the first to the second administration of the NCTM Goals Questionnaire (See Appendix C for the questionnaire.), but he did exhibit one expansion of definition. In this section, Scott's definitions for each goal on the first

and second questionnaires are presented. (For a complete description of each goal, as given by the NCTM [1989], see pages 4–5.)

Valuing:

First definition: By valuing math and learning as much as you can about it gives you knowledge and as they say knowledge is power. So by to value math, you can become powerful or just learn more and work on your math skills, at a job, at home, or at school.

Second definition: It means to know that math is important and you should know that you should want to accel [excel] at math.

Confidence:

First definition: To be confident in your mathematic [mathematical] ability means you must know what form of math your [you're] working with, to know that you can solve it, and to know you can sure try to figure it out.

Second definition: To be confident means to have the will to concentrate on a problem long enough to solve it.

Mathematical problem solving:

First definition: Using math and rational thinking a good problem solver will come up with the most rational answer or explanation.

Second definition: To be a mathematical problem solver, you need to know logic and reasoning.

Mathematical communication:

First definition: To communicate mathematically you must label and explain your work verbally as well as on paper . . . using as many technical math terms as you can.

Second definition: Being able to communicate is very important. You need to know how to communicate through words, computers etc. to really understand math.

Mathematical reasoning:

First definition: To reason mathematically, you must think in logical terms. Reasoning go [goes] along with rational thinking.

Second definition: Reasoning mathematically goes along with problem solving.

Scott expanded his definition of mathematical communication by including computers, in addition to words, written or spoken. In his second portfolio selection justification he clarified his thoughts about the use of computers. "To get an exact representation of

the picture by the computer helps to communicate or demonstrate the picture much more accurately and clearer." Scott's definitions were not in conflict with the intentions of the Curriculum Standards (NCTM, 1989), but expansion of his interpretations would have made them more closely aligned with the NCTM's interpretations.

Scott and the NCTM Goals Portfolios. The length of Scott's justifications for selections in his NCTM Goals Portfolio I diminished significantly from his initial responses on the NCTM Goals Questionnaire. When asked about this, his response was: "I was in a rush. I didn't finish some of them." In addition, the teacher reported that Scott had vocalized this complaint when she distributed sheets for justifying their selections for the NCTM Goals Portfolio I: "I am really getting sick of this." On each sheet was a statement such as, "Students will learn to value mathematics." The students were to make an appropriate selection and write their reasons why it exemplified the particular category, for example, the category of valuing mathematics. According to the teacher, Scott was "sick of" answering the same questions for both this portfolio and the NCTM Goals Questionnaire.

In an interview after the NCTM Goals Portfolio I was turned in, the researcher posed this question to Scott: "Do you think that continuing with these portfolios is a valuable experience?" Scott replied, "Yeah, I think they are good experience. The same questions, answering the same questions periodically, is kind of stressful – but, yeah." During this interview, Scott also indicated that he liked the way they had compiled portfolios the year before (Best Piece Portfolio) more than he liked selecting pieces to demonstrate the NCTM goals. But again, Scott felt the requirements were too repetitive even for the Best Piece Portfolio. About the Best Piece Portfolio he said, "This is easier, but the same every time. Ninety per cent of my portfolio selections are my tests and I usually use the same criteria – if I got a good grade, if it shows all the

work we did throughout the module.” During the semester of the study he chose all tests for his Best Piece Portfolio.

It was interesting that for his NCTM Goals Portfolio I Scott did not select any tests. For all five of the goals, he selected his responses to two open-ended mathematics problems that his teacher had given as an assignment. The problems were not from any of the modules the students had completed and they had worked on these same problems as part of a year-end assessment the previous spring. Therefore, they were doing the problems for a second time. Scott wrote very little to clarify why he selected the open-ended problems. For example, about valuing he wrote: “In the question about the grasshoppers, by the info. given, even trying to solve the problem shows that you value mathematics.” It is not apparent what this meant because he did not elaborate on his idea of valuing. He may just have been tired of answering the questions.

Scott received a failing grade on the NCTM Goals Portfolio I for incomplete justifications and because the teacher did not think he had expended much effort in selecting portfolio items. In the second formal interview, the researcher could tell that the teacher was disappointed in Scott’s portfolio. The researcher asked her whether she conveyed her disappointment to Scott when she gave back the portfolio. She said that she hadn’t, but that she thought he must have known by looking at his grade. She had not returned the NCTM Goals Portfolio I to the students, but had just handed each student a slip of paper listing the grade they had received on each selection and justification. She said that she would really like to talk to Scott about improving his portfolio at the end of the semester, but she didn’t know when she would have an opportunity to do so.

The teacher did not think that Scott had provided correct solutions to the open-ended problems that he had selected for his portfolio. However, when the students

provided their solutions for the problems, she did not give them feedback, but just awarded points for completing the assignment. In the following excerpt from an interview, the teacher discussed her frustration with Scott's selection of these problems and how lack of feedback on his work may have been a problem.

Like Scott's problems (laughs), he didn't do any right and he is picking them for his best work and I am like "AHHHHH." (laughs). And he doesn't realize that that is not a good selection which is also a problem with grading them the way that I did on that one and not choosing to take time to go over them. . . . When he did those problems, he felt he did them right. So in his mind . . . they are good for him. Because he has not had any other person telling him "no, that's not what it was." But (laughs) I should have wrote comments on it like "NO" (laughs) "NO, NO, NO." But he got points for doing it.

The teacher believed that Scott felt his solutions to the open-ended problems were good and so selecting them was perfectly acceptable to him. He had said earlier that he was confident in his mathematical ability even though his mathematics scores on standardized tests were low. This episode demonstrates that portfolios provide feedback for teachers about how their students think and, in this case, reflects upon how the teaching strategies and lack of feedback contributed to students' misunderstandings. If the teacher corrects this in the future, then portfolios have influenced future practice. If not, the teacher is at least made aware of flaws in her practices.

Scott also made the point that he was comfortable setting his own guidelines.

Interviewer: What would happen if the teacher did not set guidelines [for the portfolios]? How would you feel about designing your own portfolio?

Scott: (long pause) It wouldn't be that much different from other things we have had to do.

Interviewer: Would it be hard for you to set your own guidelines?

Scott: No.

Scott demonstrated confidence in his capabilities by comments and actions. The teacher mentioned to the researcher that she could sense his confidence by reading his writing and examining his portfolio selections.

Scott was absent from school for several days before Christmas break and for two days after the break. He had gone to California to visit relatives. Therefore, he was not in class during two of the four portfolio work days previous to the due date for the NCTM Goals Portfolio II. When he returned to school and the teacher informed him that the portfolio score would replace the semester test grade, he replied, "Good deal!" During the first day that Scott was back, he spent most of the class time visiting with Micheal about his trip and organizing his make-up work. He was confused about the difference between the year-long portfolio (The teacher sometimes referred to the Best Piece Portfolio by this name.) and the semester portfolio. In class he said, "Isn't it [the year-long portfolio] the semester one?" During the second day that Scott was back, the fourth day the teacher allotted for portfolio work, Scott asked how they were to present their portfolio. For the rest of that class period, Scott completed make-up assignments that did not include selecting or justifying portfolio items. The researcher's observation notes revealed that he asked only those two questions, did not discuss the portfolio with any other student, and did not use any of the two class periods to work on the portfolio. In the final interview, Scott verified that he did not use class time to work on his NCTM Goals Portfolio II. "I was making up work from when I was gone. . . . I didn't get a chance to work on my portfolio. I did that at home."

Scott was aware that his NCTM Goals Portfolio I needed work as he refined it to develop his NCTM Goals Portfolio II. When the teacher asked the students to reflect upon their NCTM Goals Portfolio I in a journal entry, Scott responded with the following statements:

I did not put very much effort into my portfolio even though I had intended to. The reasons were because I procrastinated [procrastinated] for so long and had a hard time trying to discover new info. So by [the] time I realized I had to get them done I was cut short of time from my laziness [laziness]. . . . This time I plan to look through my module collections more thoroughly [thoroughly] and to get it done good before its [it's] too late. If I work on it before the deadline, I'm sure I'll do a good job.

Scott's Final Perceptions of the Portfolios. In the final interview, the three focus students were questioned about their opinions of whether the portfolio was a good method for demonstrating attainment of the NCTM student goals. However, recall that Scott's definitions for several of the goals were not as complete as the definitions given by the NCTM in the Curriculum Standards (NCTM, 1989). Therefore, he based his opinions about the value of the portfolio for demonstrating the goals upon his own interpretations of those goals.

When Scott was asked whether a portfolio was a good method for providing evidence that a student valued mathematics, the following exchange ensued:

Scott: Yes and no. I look at it as if the student puts time and effort into finishing it [the portfolio] and doing a good job, that would show that they value [mathematics]. If they just completed it to get it done, that wouldn't show [valuing].

Interviewer: Are you saying that it is the whole portfolio that shows you value it [mathematics]?

Scott: Uh huh [yes].

He advocated that the whole portfolio, not just a single selection, exhibited a student's valuing of mathematics. His opinion was consistent with the portfolio choice he had made for his eleventh grade end-of-year portfolio, when he had selected his entire portfolio to show that he valued mathematics.

In the following interview excerpt, Scott shared his opinion about the portfolio as a demonstration of his confidence in his mathematical ability:

Scott: Confidence in math is having a tough problem and sticking with it and, to me, that is just getting it done and not giving up on it.

Interviewer: Do you think that you can show that you do that by putting something in a portfolio?

Scott: Yeah, if you have a long problem that requires a lot of work and a lot of different maths, different equations, things like that, and understanding it and knowing what you are doing.

Scott's definition was fairly simple, he would find a difficult problem and then show that he could do it.

Scott clarified his definition of problem solving while answering the question of whether a portfolio was a good method for demonstrating this skill.

Interviewer: Do you think you can put something in a portfolio that shows you are good at problem solving?

Scott: Yeah. The problem I picked is (shuffles through the portfolio looking for the selection) something that it's more you have to find a solution and there might be more than one solution. It's not just $5 + 3 = 8$ or something like that. You have to go through and use your logic. . . . It's choosing the math you think would best solve the problem. You choose your own type of math to solve the problem.

Interviewer: You think that you can demonstrate that in a portfolio.

Scott: With the right problem.

Scott concluded that only certain types of problems would demonstrate a student's ability and he naturally based this opinion upon his own definition of problem solving. One aspect of Scott's interpretation, "that there might be more than one solution," aligned closely with this aspect of the NCTM's interpretation, that "some problems also should be open-ended with no right answer" (NCTM, 1989, p. 6).

In the final interview, Scott shared a definition of mathematical communication that was closely aligned to the NCTM interpretation of that goal.

Interviewer: How about communicating mathematically. . . . Do you think you can show it in a portfolio?

Scott: Yeah, communication between math is showing diagrams on computers, working in groups, showing notes, describing math in words instead of numbers, that kind of communication.

Scott had expanded his definition of communication from the fall NCTM Goals Questionnaire when he had defined it as "to label and explain your work verbally as well as on paper . . . using as many technical math terms as you can." Now he was including group communication and computer diagrams. During the portfolio presentations, Scott said that mathematical communication was the most important of the five goals. "Being able to communicate mathematically is more important than any other ones." It is not apparent why he expanded his interpretation of mathematical communication. The researcher did not observe the teacher making any comments, written or oral, that would have precipitated this change.

All three students struggled in forming an opinion of whether the portfolio could serve as a method for demonstrating mathematical reasoning. As the researcher questioned the students, it seemed that the problem was with their inability to define it in concrete terms. Scott appeared to be the most confident about his selection, but he had proven himself to be a confident student by his actions and words throughout the semester.

Interviewer: We have the last one. (shuffles through the portfolio) That is reasoning mathematically. What about showing that in a portfolio?

Scott: (long pause) That was hard. That was probably the toughest one to answer. 'Cuz it kind of goes along with problem solving. It's just using your logic and picking the math you need to use to solve the problem.

As the interview progressed, Scott indicated that he had difficulty defining mathematical reasoning which made selecting an appropriate item difficult, as well. He had written this justification for his portfolio selection:

Using math reason to determine an answer to a problem that has several answers can be difficult. I used my best judgement [judgment] to come up with the answer I did. It was the most logical answer I could come up with using my ability to reason mathematically.

Both his interview responses and his written explanations of mathematical reasoning were vague.

In this final interview, Scott reacted favorably to the portfolio experience. He turned in a completed portfolio, although it was one day late. His justifications were again long and descriptive as they had been at the beginning of the year and during the previous year. His presentation was about 3 minutes long and he recommended that his school implement portfolios for evaluating their new mathematics curriculum. At the end of the semester, he reported these benefits of the portfolio experience:

I have really thought about that math is important instead of something that you have to learn because everybody wants you to and how to communicate in words involving math. (long pause) I never really thought about communication of math or valuing math or problem solving or anything like that until this portfolio.

In the final interview, he maintained his strong support for the type of mathematics program he had participated in these past three years.

My brothers will be going to high school and I just hope they get the same chances I did. I mean I really like the SIMMS math. I feel privileged to have been able to take it because a lot of kids I just see them doing book work all the time. It's just the same problem over and over and my class here is the only one it has been offered to. I hope they will spread out more and have more for the other classes.

At the end of the semester Scott did leave the class, but he was not convinced that he had made the right decision.

I wanted to stay in it [SIMMS], but I haven't had the chance to take advanced P. E. And I guess I sort of regret it now. I could change it if I wanted to, but I'm stuck in the middle. I want to do both. I want to take math, but I want to take advanced P. E. and I can't.

Sports and activities were a high priority in Scott's life. The choice between mathematics and P. E. was not an easy one.

Of the three focus students, Scott was the most difficult to interview. The researcher had to rephrase questions continuously in an attempt to clarify his answers. She often had to wait and wait for Scott to think through his ideas before responding. His response to many questions was, "Uh huh [yes]." However, his writing was lengthy and descriptive, providing much more valuable information.

Profile of the Focus Student, Kristin.

Kristin's History and Experience with Mathematics. Kristin was one of the original 16 students who had begun in SIMMS Level 1 mathematics as a ninth grader. She had completed both Level 1 and Level 2 SIMMS, but only part of Level 4 during her eleventh grade school year. She was asked the following question: "Think about your 'life' in last year's math class. In what ways were your experiences better, worse, or the same as other years? What was the most important thing that you learned?"

[Last year] began kind of bad because I was getting bored of the same teacher and the same hour. As time went by I began to get back in the swing of things but I've never been very motivated about this class. I felt bad because Mrs. O. might think it is her fault and its not. After about 3 months I left and went to Utah. My experience there was very different than my experiences here. The math itself was so easy that I didn't even have to try. Most of the things I had already done. I was in Geometry in case you didn't know. I started to sluff all the time because I could and still have a C average. The math was one answer questions and I didn't have to really think logically to come up with an answer. It made me forget how to answer with my mind and words not #ers [numbers]. I almost quit going altogether and that is when I moved back here. When I moved back I was so relaxed in my math class that I caused myself to fail. I also forgot how to really answer a question. This class isn't easy, but its not hard. Last [year] had some bad things like failing but also some good things like failing.

Kristin clarified her final contradictory statement about failing in an interview. Failing had been "bad" in the sense that her grade was unacceptable, but it had been "good" in that it made her realize she needed to improve her work habits.

Kristin did not complete an end-of-year portfolio in eleventh grade because her teacher thought that she did not have enough material to select from after returning late in the school year. During the first month of this school year, she wrote, on a portfolio question sheet administered by the teacher, that she planned, "to finish a good portfolio [this year]. Last year I didn't get to but this year I will and it will be a good one." In an interview at the beginning of the year, she gave this advice on compiling a portfolio:

Just make sure your work's done and keep it all. And keep it organized so you don't have to, at the end, go through and find everything in different spots. Just keep it organized. At the end when you write your little paragraph, just kind of think about it and kind of think about what you did during that and write your module summaries really well.

Kristin was a new face to the researcher during the first fall observation. She had never been in class when the researcher had visited during the previous year. Before the first interview, Kristin met the researcher at the door at the bottom of the stairs leading to the interview room. She was wearing a red sweatshirt and gray sweat pants. Her long brown hair was done in a braid tied with a red ribbon and she was very outgoing and lively in her actions and conversation. She talked for a few minutes with the researcher and said she did not feel very good about her experience in Utah. She also discussed her future plans. She wanted to be a biologist noting that she felt like a walking textbook about the topic – she knew all the facts. She did not think that college was a reality because of her lack of money and her boyfriend's plans. Currently, she was working after school as a waitress for minimum wage, but did not want this as a life-long career. She seemed genuinely concerned about her future.

Kristin had some concerns about grades. She was not particularly interested in earning high grades, but did want to pass. "I am concerned about passing, you know. I want to pass, . . . but . . . I don't know. There are lots of things that are going to interfere with college . . . chances of actually going to college are pretty slim." She also felt that learning was more important than grades. "My grades are not that great, but I'm really interested in actual stuff I learn in that class [mathematics class]."

Homework was a problem for Kristin. "I have a hard time finding time to do homework. . . . And I have said so many times to my teachers, if it wasn't for homework I would just love school. I would love it. I would be there all the time." Her teacher was concerned about her attendance and Kristin's statements shed some light on possible reasons for her absences. Kristin also mentioned to the researcher that her job left little time for herself or her homework. In addition, doing well in school seemed to have little bearing on her future since college seemed so far out of Kristin's reach.

Kristin was confident in her knowledge about biology, but not in her ability to do mathematics. In the first interview, she said, "I am very confident in my biology. I love it and I really like learning about it because I love it. . . . If I would love doing this [mathematics], then I would be so much more confident in my ability to do it, because I would want to learn it," but about mathematics she wrote, "Being confident in your ability to do math is not easy if your [you're] like me."

Kristin was supportive of the mathematics program she had chosen. In a journal response just before Christmas, Kristin wrote this about whether SIMMS was "really mathematics."

Our math [SIMMS] is different but it still is math. We learn a different way and some people don't understand differences. I think our math should be taught all over the U. S. They say America is behind on education. Well then maybe we should change the way we are teaching our students.

Kristin's Interpretations of the NCTM Student Goals. Most of Kristin's interpretations remained fairly stable from the first to the second administration of the NCTM Goals Questionnaire (See Appendix C for the questionnaire). In this section, her definitions for each goal on the first and second questionnaires will be presented. (For a complete description of each goal, as given by the NCTM [1989], see pages 4-5.)

Valuing:

- First definition: To value mathematics to me means to have a knowledge and an ability to use it. To value anything you need to know how to work with it. It's the same as saying it's your favorite class or if you have a good grade on it.
- Second definition: [To value mathematics means to] care how you do and work hard to better yourself.

Confidence:

- First definition: I think being confident with math is being able to calculate quickly, being able to solve realistic problems, and working with different types effectively. You have to believe that you are good enough even if you don't always get the answer right.
- Second definition: [To be confident in your ability to do mathematics means to] know what you are doing and do it well.

Mathematical problem solving:

- First definition: Being a mathematical [mathematical] problem solver means being able to solve a math orientated [oriented] problem very easily and correctly. Being a problem solver means being able to think quick and easy. Opening your mind to other things. Problem solving is more than just math it is an everyday thing that we all do. So applying it to mathematics [mathematics] should be easy.
- Second definition: [Mathematical problem solving is] answering math problems in sentences. Most math is number orientated [oriented] and I think . . . being able to solve math problems is more than numbers. There is more to math than numbers.

Mathematical communication:

- First definition: Communicating mathematically [mathematically] means being able to tell and talk to other people about math. Being able to teach how to do a problem would show good math communication skills.

Second definition: [Communicating mathematically means to] relate math ideas and maybe even teach math.

Mathematical reasoning:
First definition: To reason mathematically means to think and be able to use reasoning everyday. Reasoning is thinking clearly and easily and being sensible about it. Just apply clear, easy, and sensible thinking to math.

Second definition: [To reason mathematically means] order and reason with order.

In her final portfolio, Kristin wrote this about her selection for mathematical reasoning: "This activity took a great deal of mathematical reasoning to do the order and all the little details correctly. Every step came very easily and I think it shows good math reasoning." She had expanded her definition of mathematical reasoning slightly from the beginning to the end of the semester to include order. It is interesting that "easy" was a component of mathematical reasoning for Kristin. However, her interpretation was not closely aligned to the interpretation intended by the NCTM.

Kristin and the NCTM Goals Portfolios. Kristin turned in a fairly complete NCTM Goals Portfolio I and received a passing score, but when the day came for the researcher to interview the students about their portfolios, she was not in school. Her teacher expressed concern that Kristin had been missing an excessive amount of school and hinted that she may even drop out. The interview had to be rescheduled.

Kristin's NCTM Goals Portfolio I was unique in several ways. She was more creative in her selections than the other students. The other students had selected only items such as tests or other "worked out" problems. As an example of this "creativity of selections," Kristin selected her eleventh grade autobiography of mathematics class (See page 100.) to illustrate how she valued math that is "harder," as she worded it.

For communication, Kristin did not include any written item on paper. She merely included this statement:

I have been learning how to communicate mathmatically [mathematically]. I have been helping one of my friends do her work while she is unable to attend school. I have noticed that I can show her how to solve and do her homework very well. Without me learning to communicate mathmatically [mathematically] she would be very far behind the rest of the class. This is the best project I have done to show mathmatic [mathematical] communication.

When asked in the second interview about her communication selection, the following dialogue resulted:

Interviewer: I noticed something very interesting in your portfolio. . . . It was this one. (referring to the communication selection) . . . [For] communicating mathematically, you had the fact that you were tutoring someone. . . . You had a piece of paper telling about it, but I was wondering if there would have been anything else you could have put in here or done to verify what you had done with your tutoring?

Kristin: Um. (pause) Maybe take samples of the work that they have done and show that. Or like videotape the actual tutoring session. (laughs)

Kristin kept this selection and justification for her NCTM Goals Portfolio II.

Kristin was still recovering from a bad cold the day of the rescheduled second interview and her responses were shorter than they had been in the first interview. Several times she laid her head down on the table and coughing could be heard constantly throughout the audio-tape. However, several important points about using the portfolio surfaced in this interview:

Interviewer: What have you learned by doing the portfolio [NCTM Goals Portfolio I]?

Kristin: Umm. I was just thinking that when I first got the questions like "What does valuing mathematics or what does communicating mathematics" or whatever that was - I was just like "what the heck am I supposed to put on here, what the heck," like I really didn't understand at all what the difference between each of them were without thinking really, really hard and now I can see more clearly

what the difference is. And I think that has really helped me a lot with that.

Kristin appreciated the critical thinking involved in defining the NCTM goals. She had tried to understand and differentiate between the goals. The conversation about the portfolio continued.

Interviewer: [Have you learned] anything else?

Kristin: Organization and completion, . . . like finishing my homework so that I will have something to put in it [the portfolio].

Interviewer: So you maybe force yourself to finish more of your work so that you have something to choose?

Kristin: Yeah and if I don't finish it, then I have to put something that is not completed in there and that shows kind of a negative not a positive.

Kristin had indicated earlier that grades did not motivate her, but now she reported that the portfolio was an incentive to complete her work. Kristin also remarked on other benefits of using the portfolio.

Interviewer: Do you think that continuing with these portfolios is a valuable experience?

Kristin: Yeah. I think we should do them. It's good for us to be able to do that -- to pick out things we think are good about ourselves. It helps us be more self confident.

Kristin appreciated the opportunity to make decisions about selecting items that would personify herself and enjoyed being in control of her own assessment. She also commented about the portfolio and presentation replacing the semester exam score: "This way we're teaching ourselves and each other what we find the best out of the class and I like that."

When the researcher asked Kristin to compare the two types of portfolios that the students used, the following dialogue resulted.

Interviewer: I had one other question that just came to my mind when I got here today. Your teacher let me see your best [piece] module selection from Motion Pixels and everyone picked their test. That kind of confused me because on those, when you do that best selection thing (the Best Piece Portfolio selections), it seems like a lot of times people pick their test, but then when you do these (NCTM Goals Portfolio selections) there weren't a lot of tests.

Kristin: Umm. I think the test is more . . . a combination of everything not just one particular thing. . . . I don't think that these (NCTM Goals Portfolio selections) have to be the best we do. They are more the specific how we value or how we communicate, or things like that, it's not exactly the best.

Kristin was satisfied with her NCTM Goals Portfolio I and the teacher seemed satisfied, awarding her a passing grade, but the teacher did provide Kristin with these written comments for improving her first portfolio to submit as the NCTM Goals Portfolio II: "Put more effort into explanation of how the item exemplifies the goal and why you picked the item you did."

Kristin was in class on all four of the portfolio work days before the NCTM Goals Portfolio II was due. She was very quiet and did not discuss her portfolio with others during any of those class periods. She was still coughing from her bout with the flu in November. During those four days, observation notes showed that Kristin asked two questions relative to portfolios. The first was on the third day when she asked the teacher if she would be giving them more directions for their portfolios. The teacher replied that she would give them a handout with some additional directions on the following day. The second question was on the last of the four days when she asked if this was the last day that they had in class to work on the portfolio. When the teacher said yes, she commented, "Then we have the weekend." During the 50 minutes of work time given on the fourth day, Kristin was observed to be examining clip-art on the computer for use in decorating her portfolio. She also spent some time visiting with another student. She did not work on the table of contents or description of herself that

was to be included in the portfolio. She turned in her portfolio on time, but it was missing the self-description. In the interview she said that she missed that requirement on the handout and told the researcher she was disappointed in her incomplete portfolio. On the day of the portfolio presentation, her presentation was about 2 minutes in length and she appeared to be ill-prepared, because she had trouble deciding what she was going to say.

Kristin's Final Perceptions of the Portfolios. As part of the final interview, the three focus students were asked whether they thought the portfolio was a good method for demonstrating attainment of the NCTM student goals. However, recall that some of Kristin's interpretations for those goals were not as complete as those given by the NCTM in the Curriculum Standards (NCTM, 1989). She based her opinions about the value of the portfolio upon personal interpretations of those goals.

In answering the question of whether a portfolio was a good method for a student to show valuing of mathematics, Kristin said that a portfolio selection could demonstrate this. However, she felt that the mathematics curriculum would determine whether you could make an appropriate selection for this goal.

I think that it would be hard in a traditional class because most of what you do is just working problems. But if you did a more variety of different types of math, I think that . . . you could pick an item that shows you value mathematics.

When asked if a portfolio selection could show confidence in mathematical ability, Kristin had very little to say:

Kristin: Yeah. (laughs) I think so. (long pause)

Interviewer: How did you feel about yours?

Kristin: That piece, I just, I had a good time doing this part, I just loved it 'cuz I knew what I was doing and I felt very confident doing it.

She reported that confidence was knowing what you are doing. She also equated confidence with loving a subject, which she had done in the first interview of the school year saying that she was confident in biology because she loved the subject. In the final interview, she said that she had felt confident while doing the piece of work she had selected. It would be difficult for another person to know how she felt while she was working on the item, but she could describe her feelings in her justification for selecting it.

Kristin's interpretation of mathematical problem solving was to solve a word problem. She based her opinion about a portfolio as a method for showing skill at problem solving on her personal interpretation of this goal.

Interviewer: How about problem solving [Can a portfolio show problem solving ability]?

Kristin: Yeah, 'cuz there's very much math in it. Again I chose a word problem. I am not very big on just numbers. . . . There is more to math than numbers 'cuz look at all the stuff that they do in space and . . . science uses it, everything uses math. There is more to it than numbers.

Interviewer: So you would vote that a portfolio can show that [problem solving]?

Kristin: Yeah.

As she had done for her NCTM Goals Portfolio I, Kristin had included no written work in her NCTM Goals Portfolio II to demonstrate her skill in mathematical communication. She used tutoring another student as her selection and provided a written description of her experience. However, in the interview she talked more about group communication.

Interviewer: How about [showing] communicating mathematically [in a portfolio]?

Kristin: (long pause) With the way we work in groups, the communicating mathematically could be developed much better than not. And (pause) it would be kind of hard to show that working in groups is communicating mathematically, but (pause)

you might be able to find a piece that would show communicating mathematically.

Interviewer: So you are thinking more of [communicating] in groups?

Kristin: It would be hard to communicate with yourself mathematically. Well, you could communicate with yourself mathematically, but that's not exactly the thing they are trying to get across, I think.

Interviewer: And you still kept with your communicating with another student [as your portfolio selection]?

Kristin: Yes.

Kristin was still wrestling with her own personal definition for mathematical communication. Her definition did not expand during the semester to become more closely aligned to the NCTM's intent for that goal.

Kristin seemed very unprepared to answer the question of whether her portfolio, or any portfolio, could demonstrate mathematical reasoning. She also realized that she had not placed the correct selection in her portfolio. By this time in the interview, the researcher had the impression that Kristin had worked very little on this final portfolio and Kristin did admit that she spent little time on it. Her first portfolio had been complete and she felt little effort was needed to refine it as the NCTM Goals Portfolio II. Her selections were identical to her NCTM Goals Portfolio I selections and the only difference between the two portfolios, I and II, was that her written justifications were slightly longer.

Interviewer: And how about reasoning mathematically [showing it in a portfolio]?

Kristin: (long pause) Yeah. (speaks hesitantly, laughs, long pause)

Interviewer: You picked some order oriented [item] (pointing to her selection).

Kristin: Oh, OK. That is what I was thinking. When you do this particular one, you have to do everything in a certain order and you have to be able to think those through and be able to reason which one goes in which order and all that. So that is why I

picked this piece. Do I have the right piece? . . . I think I put the wrong one. I wanted this one module thing, but I didn't do it.

Interviewer: You were thinking of order?

Kristin: Yes, it was in this module because you had to do it step by step or else you don't get it right.

After Kristin finished discussing her module selections and showed her hesitancy on several of the questions, the interviewer pursued the idea of defining the goals.

Interviewer: Did you have trouble at the end defining what any goals meant?

Kristin: (long pause) Probably the hardest one was math reasoning. 'Cuz it is kind of hard to pick an item that you actually reason with. There is more to reasoning than just solving questions.

Interviewer: So that is the one that gave you the most problem?

Kristin: Yeah.

In the final interview, Kristin said that she was glad she had returned to a smaller school and the SIMMS mathematics class after her experiences in Utah the previous year. She was still supportive of the portfolios and pleased to have completed one. During the portfolio presentations, she also said that she thought portfolios made students more confident in their ability. "It [portfolios] helped me to be able to communicate and be able to explain myself. . . . Portfolios help students to be more confident." She also recommended portfolios as an assessment method for her school's use. "I think that they should be used in our curriculum. I think that it would be a really good idea just for students to learn to have confidence in themselves and to be able to see that they are growing at something and that they could be learning more."

Of the three focus students, Kristin always had the most to say during the interviews. In the opinion of the researcher, she was the most thoughtful and reflective of the three students and possibly the most complex. She was eager to learn and loved learning, she worried about grades but not enough to do her homework, and her future

seemed so precarious. One of her final writings in her portfolio seemed to capture the poignancy of her situation:

I picked this piece to show that I can and have intelligence [intelligence] – even though my grade doesn't show it. . . . I know I am smart but no one else knows that. Maybe this assignment will help people see that I am smart.

Profile of the Focus Student, Mandy

Mandy's History and Experience with Mathematics. Mandy was the only focus student who was new to the SIMMS mathematics curriculum. The following excerpt from the self-description she wrote for her portfolio provided insight into Mandy as a person.

I live on a ranch in [name withheld]. My aunt, uncle, cousins, and grandparents also live on the ranch. I have one sister, who is thirteen years old. . . . We have to travel thirty miles every day [to school]. I am very involved in various activities such as FFA, Close Up, and National Honor society.

I am planning on going to college near Portland, Oregon next year. I really enjoy children so I am hoping to major in elementary education or child psychology.

I think I am a confident, outgoing person. Math is very important to your everyday life. I like math and have realized that I will be faced with it for much of my life.

Mandy had completed three years of non-integrated high school mathematics, including algebra and geometry, at this school. At the beginning of her senior year, she wrote this autobiography about her experiences in eleventh grade mathematics when asked this question: "Think about your 'life' in last year's math class. In what ways were your experiences better, worse, or the same as other years? What was the most important thing that you learned?"

Last year I was in Math III [second year algebra] and I liked it. I can understand Algebra better than Geometry. Algebra is easier for me to understand and remember [remember] how to do it. In Geometry there are so many formulas to remember and use. I really like trying to fill in the missing numbers in Algebra to solve the problems. I really hated trying to solve story problems, though. I think that they're confusing. . . . I guess it's [solving story problems] just seeing all of the information there and having to pick out

the important information. Then once you have the important information, what do you do with it. [?]

Mandy had never used portfolios in any mathematics class before the year of this study. However, she had used journals in geometry with her present teacher and in second year algebra with a different teacher. In an interview, she commented about the journals from her previous mathematics class, "We wrote journals just if we had questions, not all the time, like, but if we had questions. . . . It's kind of neat to go back and look at it later. See how far you've come and stuff." When the researcher asked her what she knew about portfolios, she referred to a day in class at the beginning of this school year when the teacher had the other students look over their last year's portfolios. Since Mandy did not have a portfolio from last year, the teacher had given her one from John, a student from that year, who was no longer in the class.

I just kind of looked through one that John did last year and to me it just looked like they just showed some of their work that they did on the projects and like their steps and how they went through it and how they got to understand it, I guess.

When the teacher asked her to react to John's portfolio, Mandy wrote the following: "To me, I can see alot [a lot] of self-confidence in John's writing. I think people are impressed because you go through the kid's steps of learning and how they improve."

Since Mandy was new to the class, the researcher identified her easily during the first classroom observation. Before the first interview, the researcher met Mandy at the bottom of the stairs leading to the interview room. She was wearing jeans and a T-shirt that said "GUYZ" on the back. Her pale blonde hair was in a French braid. She talked for a few minutes about her plans for the future. She wanted to be an elementary teacher and considered attending college in Oregon. She provided insight into her choice of the SIMMS class.

Well, Math IV didn't really fit into my schedule and I really wanted to take a math next year for college. And so I went and talked to Ms. Olsen about it and she said you learned basically what you learn in Math IV. And, then, I liked working on the computer, too, and I couldn't fit a computer class into my schedule either.

One interesting fact about Mandy was her insistence that she was not "good" at "story problems." She mentioned this in her eleventh grade autobiography (See the beginning of this section pages 112–113.) and when she was asked to provide an autobiographical sketch of herself as a math student.

I like math alot [a lot] and I'm pretty good at algebreic [algebraic] problems. It's just when I have like a story problem with lots of information that it's hard for me to pick out what information to use and how to use it. So I really like algebra problems and I don't like story problems. If you can do something well, then you feel like you're successful at doing it and if you have a hard time, then [you] feel like you're failing. You just don't feel like you're a failure, you just don't feel successful.

SIMMS module assignments have few computational problems without an application. Almost all problems are written in words and, in some cases, students have to supply some of the information needed to do the problem. And, yet, Mandy expressed how she liked this class during the first two interviews. During classroom observations, she was seen by the researcher to always be busy, working alone or with other students, depending on the format of the class that day. She also helped other students work with the graphing calculator. The researcher asked her how she dealt with the story problems in SIMMS since she had so often expressed her dislike of them.

Interviewer: During this semester you have said that you dislike story problems. To me, I thought SIMMS was story problems.

Mandy: It is definitely [story problems]. I don't know. I guess I kind of like it because it makes me have to do them so I'm getting more used to it. . . . It's giving me more practice with them.

Mandy appeared to be a student who accepted what was considered to be beneficial to her and she planned to do whatever was necessary to be successful.

As the semester progressed, Mandy did not appear to be completely satisfied with her choice in taking SIMMS mathematics. In a journal response just before Christmas, over three months into the school year, Mandy wrote this about whether SIMMS was "really mathematics."

I think SIMMS is math but I sometimes wonder how I'll do in college. This is only my first year in SIMMS and my last since I'll be graduating but I don't know if it will help me with normal math. I'm afraid they'll expect me to know how to do something and I won't know how.

Mandy's Interpretations of the NCTM Student Goals. In answering the first NCTM Goals Questionnaire, Mandy's handwritten responses filled several pages. Her responses were also fairly lengthy in answering the second questionnaire at the end of the semester. Recall, that the teacher did not discuss her interpretations or the NCTM (1989) interpretations of the student goals with the students. As a result, interpretations of the goals were not the same for each student nor were they particularly accurate. During the semester, some students altered or expanded their definitions. Mandy expanded two of her definitions somewhat from the first to the second administration of the NCTM Goals Questionnaire (See Appendix C for the questionnaire). In this section, her definitions for each goal on the first and second questionnaires are presented. (For a complete description of each goal, as given by the NCTM [1989], see pages 4-5.)

Valuing:

First definition: To value mathematics [mathematics] means to understand the importance of how much mathematics [mathematics] is used in today's world. Almost any kind of job requires knowledge of some form of mathematics [mathematics].

Second definition: Some of the math you're taught, you find yourself asking why you are doing this because you'll never use it again. Math is used in most jobs, and when you know why you're doing it, it makes you value it more.

Confidence:

First definition: If you are confident in math, then you aren't afraid to try new problems. You may not understand the problem at first, but if you have confidence you just keep working through it until you understand. . . . Once I understand how to do it then I'm really confident about it.

Second definition: To be confident you have to prove to yourself that you can do anything and just keep trying until you get it. Once you get it, you are proud of yourself.

Mathematical problem solving:

First definition: To be a mathematical [mathematical] problem solver, you can look at a problem and know the steps used to solve it. For some people it is really easy and natural to look at a problem and know the steps used to solve it.

Second definition: [Mathematical problem solving is] mainly solving story problems. You have to organize the information in the story problem and decide how to use it. Once you get the steps down and can utilize information, problem solving can be easy.

Mathematical communication:

First definition: If you're trying to explain math to someone you have to be a good communicator [communicator]. To be a good communicator, you have to use words and phrases they'll understand.

Second definition: To be able to work with a partner and get somewhere with a problem, you have to be able to communicate with each other. . . . Using the computer and printing out work is also [mathematical communication]. . . . You can show someone how something works and can refer to the print out, so they SEE how it worked.

Mathematical reasoning:

First definition: To reason mathmatically [mathematically], you have to be a good problem solver. Actually before you're a good problem solver you have to be able to reason out the information that you have. You have a math problem and its information and be able to reason out the information, so you know what to do with it and how to use it.

Second definition: To do story problems you have to be able to reason mathematically. You take the information of these problems, reason out the information and apply it to solving the problem. When you read a math problem, it is filled with information and you have to be able to know how to use the information.

Her two definitions that appeared to expand were those for mathematical problem solving and mathematical communication. In her first definition of problem solving, Mandy implied that it was a matter of "knowing" what to do by looking at the problem. In her second definition, she had added organizing and utilizing the information. For mathematical communication, she included computer print-outs as a form of mathematical communication. This expansion was probably due to a comment made by the teacher. During the entire semester, the teacher was observed to provide only one comment to a student which altered or expanded the student's definition of a goal. That was a written comment given to Mandy for aiding her in compiling her second portfolio one week before the NCTM Goals Portfolio II was due. The teacher wrote, "On communicating mathematically - consider this: do you communicate mathematics using graphs, diagrams, equations, etc.? Is all communication oral?" This was the teacher's definition of mathematical communication as relayed to the researcher during the first teacher interview. Mandy kept her old definition, but incorporated the teacher's definition into her own by selecting computer print-outs, in this case a computer-generated diagram, for her portfolio.

Mandy and the NCTM Goals Portfolios. For her NCTM Goals Portfolio I, Mandy selected a piece of work for each of the goals and wrote a justification for each. She received a passing score for her portfolio and the teacher was pleased with her work. She had worked on her portfolio over the weekend and commented:

I didn't think that there was enough class time, really. 'Cuz, basically, our test took so long 'cuz we were supposed to have time on Friday to work on it in class Friday, but our test took the whole period on Friday. [If I had more class time] I probably would of like talked [with other students] about [the portfolio] but, I don't know, maybe it's good just to do it on your own instead of getting other people's ideas in there.

After compiling her NCTM Goals Portfolio I, Mandy was rather indifferent to the portfolios. When asked if she thought continuing with the portfolios would be valuable, she replied, "I know it is kind of hard for me to say because I haven't been in it very long, but I don't know if they have really helped me a lot." She also expressed what might be considered boredom with the task in this interview excerpt.

Mandy: Sometimes it just seems kind of repeated, everything we do in there [the portfolio] is kind of the same.

Interviewer: Do you mean like first you had to tell what reasoning meant and then you had to pick it?

Mandy: Yeah.

However, she did mention the critical thinking aspect of working on her portfolio. "I guess it makes . . . you think about what you are doing and why. Like some reasons behind it."

Mandy was in school for all four of the portfolio work days before the NCTM Goals Portfolio II was due. During those four days, Mandy asked the teacher three questions directly relating to the portfolios. On the first day when she was to reflect on her NCTM Goals Portfolio I (See Appendix C for the journal entry.), she asked the teacher, "What was it we put in our portfolio?" The teacher responded by listing the NCTM student goals. On the third day when the teacher instructed students to write justifications for their portfolio selections, Mandy asked her what to do with her old justifications if she was writing new ones. The teacher told her to discard the old justifications. On the fourth day Mandy showed the teacher a paper and asked whether it was to be included in her portfolio. The teacher replied, "Not unless you choose it." During the third day and for 25 minutes of the class period on the fourth day, Mandy worked alone at her desk looking through papers, writing, and stapling. For the final 25 minutes of class on the fourth day, Mandy worked at the computer. She was

observed to produce and print a table of contents for her portfolio. She did not work on the self-description that was required for her portfolio. As she was arranging her portfolio, she asked one student a question that the researcher could not hear. The other student's response was, "I have no idea." When the other student could not answer her question, she did not ask the teacher. The researcher thought it was interesting that she asked only three questions, because she said in her final interview that she liked having class time to work on the portfolios. "I thought it was better to do it in school then having to do it at home because then, if you didn't understand something, then she [the teacher] was there."

Mandy's Final Perceptions of the Portfolios. In the final interview, focus students were asked their opinions about the portfolio as a method for demonstrating their attainment of the NCTM student goals. However, recall that Mandy's interpretations of the goals were not as complete as those given by the NCTM in the Curriculum Standards (NCTM, 1989). Her opinions about the value of the portfolio for demonstrating these particular goals were based upon her limited interpretations of those goals.

Mandy had formed the opinion that a portfolio selection to show that she valued mathematics would depend upon the mathematics course. She had this to say about show how she valued mathematics in her portfolio:

As I said in here [pointing to her justification] . . . in other math you don't really know why you did something and in the SIMMS, it is kind of neat, because they tell you, like in different fields, where you would use the math that you were doing.

Mandy had selected an assignment where they had learned the application of matrices in making movies. Mandy did not think that she could always find an application of

mathematics in just any mathematics course, because her personal definition of valuing was mathematics' usefulness and application.

Mandy was not sure about using a portfolio for the purpose of conveying a student's confidence in mathematical ability.

Mandy: (long pause) I don't know. Confidence, I mean, I guess, like if you have to show it through math, through something you did, then this one made me feel confident because I did good on it. But I don't know if I'd, like I might just, I don't know, like I might just tell instead of showing.

Interviewer: So would you suggest maybe an interview or (trails off).

Mandy: Yeah, or something, or maybe . . . an essay without paper.

Mandy did remark that she felt confident after she did well on her selection, which was a test on which she had earned a high score. It is interesting to note that at the beginning of the semester Mandy had written this about another student's portfolio: "To me, I can see alot [a lot] of self-confidence in John's writing [in his portfolio]." Yet, now, she did not mention that her portfolio showed her confidence.

Mandy was not sure whether her selection was demonstrating problem solving ability, but she felt that a portfolio did have the potential to display a student's ability in that area.

I think problem solving you can show really good in portfolios, but you have to have (trails off and then pauses). I don't know if what I had was good problem solving, but I think that you can have a piece of paper that shows how you solve problems.

Mandy's definition of problem solving was solving story problems and her selection satisfied her definition, although she was not sure whether it would conform to someone else's definition.

Recall, that during the semester Mandy had expanded her definition of mathematical communication. She had originally defined it as explaining mathematics

to another person so that they would understand. Now she was including graphs or diagrams.

Interviewer: OK, here is communication. What do you think about that one [showing it in a portfolio]?

Mandy: (pause) Yeah, I like, I think that the work I had was good because you can communicate, like get a graph, and then you can communicate with other people. And then when we worked on the computer, we did it in groups so that we had to communicate with each other.

Interviewer: So two things, communicating in groups with someone else and also showing something with graphs?

Mandy: Yeah.

Interviewer: So you think a portfolio could [show communication]?

Mandy: Yeah, I think so.

Mandy's selection was a computer print-out of geometry translations that she had completed with her group. The selection itself would not demonstrate to the reader her group communication skills, but her explanation was that she talked with others while deciding how to perform the translations. The reader of the portfolio would have to infer that she had the ability to share ideas in a group. This skill would not be explicit in the item Mandy selected.

Mandy was undecided about demonstrating mathematical reasoning with a portfolio selection.

Interviewer: How about this one [showing mathematical reasoning] (Interviewer refers to the selection.).

Mandy: (long pause) Actually I thought this one was really hard to find something for.

Interviewer: Can you pin down why it was hard?

Mandy: (long pause) Yeah, I just didn't know how to really explain it, with a math paper I guess.

Interviewer: Can you think of anything else other than a portfolio?

Mandy: (long pause) I don't know. Maybe if you guys could like give questions or something. I don't know what kind of questions.

Interviewer: Would you want to answer them orally or would you want to write something down?

Mandy: Either way probably.

The researcher attempted to determine whether Mandy was comfortable defining mathematical reasoning.

Interviewer: Did you have trouble deciding what mathematical reasoning was?

Mandy: Yeah . . . (pause) . . . yeah, it was kind of hard. . . . Yeah, not knowing exactly what you are doing from the beginning I guess.

From the very beginning of the semester, on the questionnaire, in the portfolio justifications, and in the interviews, students had trouble interpreting mathematical reasoning.

During the interviews, Mandy always appeared very honest. During the entire semester she seemed hesitant about SIMMS mathematics and the portfolio. In the final interview she said she did not know what she had learned or gained by doing the portfolio. She did not think it would be of any future use for her: "I can't see where, after this, we would really use this." Mandy was confident about her future plans and wanted to excel in school. In the opinion of the researcher, she had been comfortable in her previous mathematics classes and was unsure about this new mathematics program. However, she was successful, as far as grades go, in the SIMMS classroom. She was awarded the highest score on the NCTM Goals Portfolio II.

An interesting event occurred on the final day of this study. Mandy had participated in her final interview on January 12, stating that portfolios were not worth much in her estimation. Then on January 17, when Mandy saw that the researcher was present in the classroom, she rushed up to her and indicated that she wanted to change

what she had said in the interview. The researcher was surprised and asked her what she meant. She stated she had been thinking more about the portfolios as she prepared for her presentation. When the researcher asked her what she wanted to say about the portfolios, she said, "I have changed my mind. I think portfolios would be really good to send to colleges to show a student's work." The researcher thanked Mandy for sharing her ideas and wrote down her words.

It is true that Mandy received an excellent score on her portfolio, but she had not seen that score at the time of her comment to the researcher. She came up to the researcher before the beginning of class on the day of the presentation and the teacher did not hand back the portfolios or score sheets until the class period began. Mandy did not have an opportunity to see her score before she made her comments to the researcher. Her score could not have directly influenced her change of heart.

Interpretations of the NCTM Student Goals

At the beginning and the end of this study the students were asked to define, in their own words, the NCTM goals, which included: (a) students learn to value mathematics, (b) students become confident in their mathematical ability, (c) students become mathematical problem solvers, (d) students learn to communicate mathematically, and (e) students learn to reason mathematically. It is important to note that prior to administering the NCTM Goals Questionnaire, the teacher did not discuss the goals with the students nor did she provide the students with her own personal definitions. At the end of the previous year, seven of the students had compiled a portfolio to demonstrate these same goals, but they did not share their definitions or portfolio selections with other students. (See Page 76 for a discussion of the previous

year's portfolio.) Throughout the semester the teacher chose not to discuss the meaning of these goals.

This section presents several comparisons of the NCTM goals definitions. To accomplish these comparisons, the NCTM definition from the Curriculum Standards (1989) is presented for the particular goal and then a discussion of similarities and differences in the student and teacher responses follows with comparisons being made to the NCTM definition. Recall that the researcher asked the teacher for her definitions during the first interview.

The NCTM definition from the Curriculum Standards (1989) for "learning to value mathematics" is:

Students should have numerous and varied experiences related to the cultural, historical, and scientific evolution of mathematics so that they can appreciate the role of mathematics in the development of our contemporary society and explore relationships among mathematics and the disciplines it serves: the physical and life sciences, the social sciences, and the humanities. Throughout the history of mathematics, practical problems and theoretical pursuits have stimulated one another to such an extent that it is impossible to disentangle them. Even today, as theoretical mathematics has burgeoned in its diversity and deepened in its complexity and abstraction, it has become more concrete and vital to our technologically oriented society. It is the intent of this goal—learning to value mathematics—to focus attention on the need for student awareness of the interaction between mathematics and the historical situations from which it has developed and the impact that interaction has on our culture and our lives. (NCTM, 1989, p. 6)

The nine students presented a total of 14 ideas about what it means to value mathematics. Seven of those ideas could be summarized by saying that to value mathematics means to realize that you will need to use it in the future in life and/or in a job or career. Other student responses to this question were that it means you care about mathematics or the learning of it, that you use it every day, that you do your work in math class, and that you have fun in your mathematics class. One statement made by a student that appears to be the closest to the NCTM goals was, "To value

mathematics means to understand the importance of how much mathematics is used in today's world."

While students did not provide definitions of valuing mathematics that coincided exactly with the NCTM description of the goal, in the follow-up interviews the students brought up several points that showed they were thinking about the "role of mathematics in the development of our contemporary society and explore relationships among mathematics and the disciplines it serves." For example, one student commented on the SIMMS curriculum in which she was enrolled. Recall, that this curriculum is integrated, interdisciplinary, and focuses upon real world applications. When asked whether she valued the mathematics she learned in school, she said,

I actually value the one that we do in SIMMS more than I did my geometry class that I was taking. It was 'cuz I could look at it and say I'm never going to use this. And then like SIMMS, like if you ever go into business, or all sorts of things, you could be using [mathematics] every day.

Another student commented, "I think it's important to learn [mathematics] 'cuz like math is part of technology."

Usefulness of mathematics was an important component of valuing that many students identified. This "usefulness" theme was also the interpretation of the teacher. She said, "For me to value it, it does have to have some kind of meaning or use. . . . It could be used in my life and I might value it." The teacher noted that a student might demonstrate the attribute of valuing mathematics by not caring so much for the grade they receive in mathematics. "If they value it, . . . they don't care so much for the grade. They really want to know it because they know they are going to need it in the future."

The students' definitions were not in conflict with the description given in the Curriculum Standards (1989), however, their views were not as broad. Students did

not mention ideas that could be interpreted as “interaction between mathematics and the historical situations from which it has developed.”

The NCTM explanation for “becoming confident in one’s own ability” is:

As a result of studying mathematics, students need to view themselves as capable of using their growing mathematical power to make sense of new problem situations in the world around them. To some extent, everybody is a mathematician and does mathematics consciously. To shop at the market, to measure a strip of wallpaper, or to decorate a ceramic pot with a regular pattern is doing mathematics. School mathematics must endow all students with a realization that doing mathematics is a common human activity. Having numerous and varied experiences allows students to trust their own mathematical thinking. (NCTM, 1989, p. 6)

Some students’ definitions of confidence involved understanding or “knowing” the mathematics itself while other definitions focused on ability to do mathematics or “knowing” that you can solve problems, do well in the subject area of mathematics, or calculate quickly. Three students’ definitions included not being afraid to try new mathematics or to “jump in” and work on any given mathematics problem. One student stated that after working a problem and not being sure whether your answer is right or wrong “you will get up and show how you got the answer no matter what.” Two students were sure that confidence was based upon understanding. One student stated that writing about mathematics made him more confident and he also could use his portfolio as evidence of his confidence in his ability to do mathematics.

One student’s comment did not fit with the other responses. She based confidence on feelings towards a subject. “I am very confident in my biology. I love it and I really like learning about it because I love it. . . . If I would love doing this [mathematics], then I would be so much more confident in my ability to do it because I would want to learn it.”

The teacher described confidence similarly to three of the students.

I think if you are confident in your ability, you’ll just plunge right into things. I think . . . you’re a risk taker. . . . They’ll take a hard problem and not leave it

blank. They have confidence in their ability to do mathematics and so maybe it is wrong, but, "This is the way I interpret the problem . . . so this is the way I am going to answer it," and not come up and ask me.

Confidence seemed to be fairly easy for the students to define although there were some differences, as there had been with valuing. Most definitions were closely aligned to the NCTM description of confidence as trusting mathematical ability.

The NCTM interpretation from the Curriculum Standards (1989) for "becoming a mathematical problem solver" is:

The development of each student's ability to solve problems is essential if he or she is to be a productive citizen. We strongly endorse the first recommendation of *An Agenda for Action* (National Council of Teachers of Mathematics 1980): "Problem solving must be the focus of school mathematics" (p. 2). To develop such abilities, students need to work on problems that may take hours, days, and even weeks to solve. Although some may be relatively simple exercises to be accomplished independently, others should involve small groups or an entire class working cooperatively. Some problems also should be open-ended with no right answer, and others need to be formulated. (NCTM, 1989, p. 6)

Students' responses varied from problem solving being something that is "easy" and "natural" to problem solving as explaining, using rational thinking, and being open-minded about new ways of solving a problem. One student noted that "problem solving is more than just math it is an everyday thing that we all do." Another student, who was new to the SIMMS curriculum this year, explained problem solving this way: "To be a mathematical problem solver, you can look at a problem and know the steps used to solve it." One student thought that problem solving ability was more inherited than learned. "SIMMS has a lot of problem solving and I have been in SIMMS for the last three years. . . . but before that I was pretty good at problem solving. I think it's natural. . . . I think math runs in the family."

The teacher's definition of problem solving matched closely with two of the students'. The first student had said, "To be a mathematical problem solver you need to have an open mind and be willing to try new ways of working through problems."

The other student had said “[problem solving is] opening your mind to other things.” The teacher’s definition was “to me being a mathematical problem solver is being one that can take mathematical problems and try various approaches and strategies and come to a solution that they feel good about and can justify and say ‘I think this answer is correct because...’”

The NCTM definition for problem solving is quite comprehensive mentioning small problems completed individually as well as problems that require sustained effort or may have more than one solution. Most definitions provided by the students could easily be interpreted as part of this broad definition. However, discussion of this goal would probably have expanded the students’ views of its meaning.

The NCTM definition from the Curriculum Standards (1989) for “learning to communicate mathematically” is:

The development of a student’s power to use mathematics involves learning the signs, symbols, and terms of mathematics. This is best accomplished in problem situations in which students have an opportunity to read, write, and discuss ideas in which the use of the language of mathematics becomes natural. As students communicate their ideas, they learn to clarify, refine, and consolidate their thinking. (NCTM, 1989, p. 6)

Two themes that emerged in students’ definitions for mathematical communication were oral communication and written communication. In the oral category were responses like “you can easily explain any sort of math problem to anybody” or you can “share your ideas with people in a group.” Students also mentioned that being a teacher means you would be a good mathematical communicator because you “tell and talk to other people about math” or that, as a student, you explain mathematics to others. Two variations in the category of “explaining to others” were that you explain it and “know what your [you’re] talking about” or that you explain the mathematics so that others can understand it. One student mentioned listening: “[You] work together and listen to your group members.” Another student emphasized that “you must understand the

terms you use.” Only one student discussed written communication. “To communicate mathematically you must label and explain your work verbally as well as on paper.”

The teacher’s definition was “communicating mathematically, to me, is when you are using your graphs and diagrams and your equations that you used in your solutions and you can also have written work. . . you are using the language of mathematics.” The teacher said that she thought students would see mathematical communication as writing or talking about how they did a problem. “[They don’t think] that you can communicate through the symbols of mathematics. . . . They just think written words or oral words . . . an explanation of what they did is what they’ll pick out.” As it turned out she was definitely right about the oral or written language, but one thing might have surprised her. Some students thought teaching math or explaining a math concept was mathematical communication. Not all students said it was explaining the work done on a problem.

The NCTM description of mathematical communication is multi-faceted involving reading, writing, and speaking. It also involves learning the signs, symbols, and terms of mathematics. In this class, the students had a narrower view of communication than what was intended by NCTM. However, as was discussed in the student profiles, two focus students did expand their definitions by the end of the semester.

The NCTM interpretation from the Curriculum Standards (1989) for “learning to reason mathematically” is:

Learning to reason mathematically. Making conjectures, gathering evidence, and building an argument to support such notions are fundamental to doing mathematics. In fact, a demonstration of good reasoning should be rewarded even more than students’ ability to find correct answers. (NCTM, 1989, p. 6)

Providing a definition for mathematical reasoning was definitely the most difficult for the students on the student questionnaire and in the interviews. Answers varied from

thinking it through, breaking down a problem, or “reasoning” out information to being open-minded or using logical thinking. Several unusual responses were that “you are able to do a math problem that you have to guess the type of math to use” and “to make a logical good guess on how to solve a problem.” One student response that seemed to be the closest to the NCTM definition was “Reasoning is knowing you can’t have this or something else.” This response seemed to imply the use of logic to solve a problem. Not one of the students ever mentioned “making conjectures, gathering evidence, and building an argument” or any ideas similar to those intended by NCTM.

The teacher did not have a concise definition for this concept either. She defined mathematical reasoning using logic. “[Reasoning is] that ability to logically think and reason through things. . . . I really view reasoning mathematically as thinking mathematically in a real logical way.” Even though the teacher admitted having some trouble defining mathematical reasoning she noted, “And yet, I think you can pick up a paper and read it and say they can reason mathematically because you can follow their logic, [but] maybe that is more communication.” In an informal discussion with the researcher, she talked about whether mathematical reasoning could be taught. During the course of the discussion she decided that it probably could, but that she was not consciously aware of teaching it.

In comparing the NCTM definition of mathematical reasoning to students’ definitions, the researcher thought that a discussion of this concept would probably have helped students to understand what it was and to realize how they use it. The teacher made it clear in the second interview, however, that she wanted the students to define each of these goals in their own way without her interference.

From the analysis of the students’ and teacher’s interpretations of the goals, it appeared that some of the NCTM student goals are not easily defined and that people do not have the same definition. Also, if a student’s definition is vague, then one would

expect the student to have difficulty demonstrating the goal with a portfolio selection. For example, the students had trouble defining mathematical reasoning. It seemed likely, then, that students would have some trouble selecting something to demonstrate their mathematical reasoning ability and experience additional difficulty in explaining their choice. The students did talk about their difficulties with mathematical reasoning in the interviews.

Perceptions of the Use of Portfolios to Demonstrate the NCTM Goals

The research question posed in this study was: What are high school mathematics students' perceptions about portfolios as a tool for assessment, that is, for demonstrating their progress in fulfilling mathematics goals? In the student and teacher profiles, their perceptions relative to the research question were presented. Since the students did not hold interpretations that were as encompassing as the NCTM's interpretations for each goal, their opinions about the portfolios for showing their attainment of the goals may only be valid for each individual student. The researcher was not in control of the teacher's actions in relationship to the portfolios. The teacher had agreed to implement a specific type of portfolio and give the researcher access to the students, their work, and the classroom, as an observer. The researcher did not train the teacher in the implementation of portfolios during the course of the research study, but merely acted as a sounding board for the teacher as she brainstormed strategies for facilitating the implementation.

The following discussion compares the students' and teacher's opinions of portfolio assessment. All of these opinions were given at the end of the semester after the students compiled the NCTM Goals Portfolio II. During each interview, the student's NCTM Goals Portfolio II was available for reference. Before the interview,

the researcher stressed two reasons for the importance of the students reporting their honest opinions. First, the researcher wanted to relay the students' ideas to interested educators because historically few students have been asked for their opinions about assessment. Second, their teacher was interested in their opinions since she desired to provide the mathematics curriculum committee with information about using portfolios from the students' perspective. The researcher went through each goal with the students and asked them to decide whether the portfolio was a good method for showing the goal. If the portfolio was not a good method, the researcher asked them to try to suggest a better method. After the teacher assessed the students' final portfolios, she was asked to rate how well she thought the portfolios demonstrated the student's abilities in each the five areas of valuing mathematics, confidence in mathematical ability, mathematical problem solving, mathematical communication, and mathematical reasoning.

All three focus students believed that the portfolio was a good method for demonstrating how a student values mathematics. The teacher had some reservations about the portfolio's demonstration of how a student values mathematics. The problem may have been in the definition. As the teacher phrased it, "Valuing something, what does that mean?" The teacher had struggled with students valuing the portfolios and had found no easy solution. The students, according to the teacher, had struggled with defining what it meant to value mathematics.

Two of the focus students felt that they could select an item to show their confidence, but the third student was not so sure. Mandy and the teacher were hesitant about the use of the portfolios for demonstrating confidence. Two varying student opinions were shown: (a) Kristin selected something she felt confident while doing and (b) Mandy selected something that she had done well on which made her feel confident. Even though non-focus students noted on the student questionnaire that

portfolios were a good method for demonstrating confidence, they offered several alternative methods. Those suggestions included taking part in class discussion, taking tests, and being interviewed. Cindy, a non-focus student, mirrored the teacher's idea that you could see a student's total confidence through all the work in the portfolio. In addition, Mandy had commented, about a previous student's portfolio (See page 113.), that she could see his confidence exhibited in his portfolio selections and justifications.

The three focus students agreed that a portfolio selection could show a student's mathematical problem solving ability, but Scott and Mandy placed the restriction of having the correct type of problem. All three focus students based how well a portfolio could exhibit problem solving upon their own definition which was to be expected as that was all they knew how to do. The students had defined the goals for themselves and then used their own judgment to select work that would show their abilities. The teacher focused on open-ended mathematics problems and, therefore, she actually could have gained information about the students' problem solving ability by methods other than the portfolio.

The three focus students had very brief answers about showing mathematical communication in the portfolios. However, they did think that portfolio selections could show this ability. The teacher had been concerned since the beginning of the school year that students were not seeing a broad picture of communication and it may be that they were unsure about their own definitions of this goal. That insecurity may have led to their short responses. Several non-focus students thought that portfolios could display ability in mathematical communication, but they had other suggestions as well. These were: (a) discussing how to solve a problem, (b) helping others in a group, (c) talking or writing to others about mathematics, (d) working with technology, and (e) working together.

The focus students struggled in forming an opinion on whether the portfolio could serve as a method for demonstrating mathematical reasoning. As the researcher questioned the students, it appeared that the problem was with their inability to define mathematical reasoning in concrete terms. The teacher's reaction to the question about the success of the portfolios in demonstrating mathematical reasoning was very strong. She was certain the portfolios had not worked for this and she had no suggestion about what would work or whether this ability can be tested or assessed at all. The teacher had no easy solution to assessing mathematical reasoning.

The students' struggles with defining mathematical reasoning throughout the semester probably made selecting an item to represent this goal very difficult. On the student questionnaire, Kathy, a non-focus student, wrote, "I don't think it can be demonstrated because others can have different ideas and opinions." Scott, Carol, Micheal, and Mandy wrote on their questionnaires that mathematical reasoning and mathematical problem solving were the same thing. Scott had been saying this throughout the semester.

The teacher repeated several times in the final interview that she had learned about the students through the portfolios and, according to the Assessment Standards (1995), that is one purpose of assessment. Even though the teacher did not think that the portfolios were a perfect assessment method of student performance relative to the five NCTM student goals, she gained information about the students through the portfolios. She had also said to the researcher at the beginning of the study that she thought traditional testing was not going to be productive in measuring the progress of students towards fulfilling these goals .

Students' Perceptions of the Portfolios

After each of the NCTM Goals Portfolios was collected, the researcher interviewed both the focus students and the teacher. During these interviews, the three focus students were asked whether they had gained anything from working on the portfolios. At the end of the semester, the teacher asked each student during the in-class portfolio presentations whether they had gained anything from working on the portfolios. Students' self-reports about using the portfolios are presented in this section.

After turning in the NCTM Goals Portfolio I, Scott appeared to dislike looking for pieces and answering the same questions as were on the fall NCTM Goals Questionnaire, but he did report learning from the experience. "I've learned to communicate math better." At the end of the semester, he reported,

I have really thought about that math is important instead of something that you have to learn because everybody wants you to. And how to communicate in words involving math. (long pause) I never really thought about communication of math or valuing math or problem solving or anything like that until this portfolio.

At mid-semester, Mandy reported that portfolios had some value as an experience, but she was not completely sold on the idea.

Interviewer: What have you learned by doing the portfolio?

Mandy: I guess it makes . . . you think about what you are doing and why, like some reasons behind it.

Interviewer: Do you think you have learned more about math because you did this?

Mandy: Umm. I don't really think that I can say that I have learned more. It's just kind of a different way of looking at it.

Interviewer: Do you think that continuing with these portfolios is a valuable experience?

- Mandy: I know it is kind of hard for me to say because I haven't been in it very long, but I don't know if they have really helped me a lot. But I think they are good to have something to refer to like if you just go back to your notebook and have just pieces of work and you don't really know where they have come from and if you have written something about it then you remember.

Mandy expressed what appeared to be her honest impressions about using mathematics portfolios. She planned to withhold her final decision about their value until she had more experience. Near the end of the semester in the final student interview, she seemed to have made her final decision saying to the researcher that she really didn't see any use for portfolios and did not think she had gained anything. However, when the researcher visited the class on the final day of the study, Mandy came rushing up and said, "Guess what? I've changed my mind about the portfolios." She then told the researcher she thought portfolios were good to send to colleges. Mandy received an excellent grade on her final portfolio. However, this could not have been the direct cause for her remark, because she did not see her grade until after she reported her change of heart.

After the NCTM Goals Portfolio I was turned in, Kristin reported that she really had to think to understand what the NCTM student goals meant.

Interviewer: What have you learned by doing the portfolio?

- Kristin: Umm. I was just thinking that when I first got the questions, like what does valuing mathematics or what does communicating mathematics or whatever that was. I was just like, "what the heck am I supposed to put on here? What the heck?" . . . I really didn't understand at all what the difference between each of them [the NCTM student goals] were without thinking really, really hard and now I can see more clearly what the difference is. And I think that has really helped me a lot with that.

She also brought up a personal benefit of using portfolios.

Interviewer: Anything else [other benefits of portfolios]?

- Kristin: Organization and completion.

Interviewer: So do you mean like finishing a task?

Kristin: Yeah. Like finishing my homework so that I will have something to put in it [the portfolio]. . . . and if I don't finish it, then I have to put something that is not completed in there and that shows kind of a negative not a positive.

Kristin had mentioned earlier in the interview, "I have said so many times to my teachers, if it wasn't for homework, I would just love school. I would love it. I would be there all the time." Her teacher verified that attendance was a problem for Kristin, but now, in the interview, she was saying that compiling portfolios made her want to complete her homework even though she usually didn't like to do it. In the first interview Kristin had said that grades were not that important to her, so grades were not her incentive for completing assignments. She said she wanted to pass, of course, but she really didn't care to compete with other students for high grades. According to Kristin's self-report, the portfolio was her motivation to do homework while grades were not. At the end of the semester, she told the researcher what she had profited from the portfolio experience.

[What I gained was] probably learning what some of the goals of math are. Going through it just blindly not knowing why you are doing that. And some of these goals help you to see what is important in math. Teaching us to do math and the teacher knowing why they want us to do math, but never telling us.

The last site visit was made by the researcher on January 17, 1996, the day of the student portfolio presentations. The teacher decided to ask all of the students whether they benefited from compiling the portfolios. Every student made a positive statement about the portfolios. Here are the students' comments:

Micheal: Actually I did gain a lot because it made me think about some of the pieces I did instead of just going through and just doing them. I actually thought about some of the pieces I did and had to come up with explanations considering like, "Students learn value for mathematics." . . . I like doing this better than I do semester exams

because it makes you actually think about your work instead of just going through and doing it.

Mandy: I think this portfolio is important to look back on later in life.

Cindy: It let me find my strengths and weaknesses. I don't know what other people did, but I picked good and bad pieces and I guess that shows what you learned.

Carol: You learn a lot about yourself and the work that you do in math.

Becky: You learn about yourself and you look more at what you do, you don't just do it.

Kathy: I actually got to look at how I value math. I had never really thought about how I value math. And the other goals, like problem solving, I never realized what that meant that way. It was good to try to demonstrate how you do value it.

Scott: I actually thought about math in different ways, like problem solving, and what it meant.

Kristin: It [portfolios] helped me to be able to communicate and be able to explain myself. . . . Portfolios help students to be more confident.

Jennie: I gained a lot from these portfolios. I learned what I liked and disliked about this class.

From their comments, it appeared that all of the students were pleased with the portfolio experience and several reported liking the critical thinking involved in choosing their pieces and defining the NCTM student goals for themselves.

All of the students submitted a second NCTM Goals Portfolio. However, one student did receive a failing score for incomplete work and turning hers in late. During the semester of the study, one student reported that the portfolio was her motivation to finish homework. At the end of the semester, a student who had been hesitant about the portfolio throughout the semester exhibited a positive attitude about compiling it. Also, two students noted learning to communicate more effectively while developing their portfolios. One student reported becoming more confident and two students came to the realization of how they personally value mathematics.

Students' Recommendations to the Mathematics Curriculum Committee

During the final student portfolio presentations on January 17, the teacher asked the students whether they would recommend using portfolios to their school's mathematics curriculum committee as a method for assessing their school's new goals for mathematics, which included the NCTM student goals. In their presentations, all nine of the students said that they would recommend the portfolios. Some of the students provided more than a simple "yes" to answer the question: "Would you recommend that we use portfolios at our school?" Their comments follow:

Micheal: Definitely, because taking tests, sometimes you do better at one time than you do at other times. I don't think that everything should be from tests. I think that there should be like a portfolio so they can learn about some of your abilities from a portfolio.

Mandy: We could keep one through high school for teachers to know you better.

Kathy: I would definitely recommend it for all the rest of the school because, like in my Shakespeare class and chemistry class, we just got back our folders with our tests. I don't think that actually shows what you learned at all because one chapter you might not understand, but there might be work in other parts of the class that you really do understand. I think portfolios show that better. Portfolios are a better way to show what you learned in class.

Kristin: I think that they should be used in our curriculum. I think that it would be a really good idea just for students to learn to have confidence in themselves and to be able to see that they are growing at something and that they could be learning more.

Jennie: I would definitely recommend using portfolios here 'cuz when you take it to college with you, it will give the school a good name.

Even though some of the students had trouble compiling a portfolio at the end of the first quarter and some mentioned struggling to define the student goals and also to select and justify items to demonstrate the goals, their final attitudes were positive

and, from their comments, it appeared that the portfolios had been a valuable experience for each and every one of them.

Portfolio Implementation Issues

As the study progressed, certain issues related to the portfolios were brought to light. Examination and comparisons of data from interviews, observations, informal conversations, and written work were key factors in revealing these issues. As issues arose, the researcher asked additional questions and focused observations to examine them. Some issues were found to be interwoven with other issues. These issues are discussed in this section.

Time and the Portfolio

During the course of the semester, time was an important issue with several facets. First, there was the time that students needed to accumulate enough material for making appropriate selections for their NCTM Goals Portfolio. Second, there was the issue of how much class time to devote to the portfolios. Third, there was the time needed for the teacher to communicate her expectations to the students. Fourth, grading time was an issue raised by the teacher, not necessarily for her, but for other teachers.

Near the end of the first quarter when the NCTM Goals Portfolio I was due, the teacher expressed to the researcher her concern that there had not been enough time for students to accumulate appropriate material for their portfolio selections. The modules had been difficult and, therefore, the students had been covering the material very slowly. Also, the teacher usually gave them unusual work, not from modules, that would provide the students with more variety from which to make selections.

However, their slow progress prevented her from assigning this extra work. After the NCTM Goals Portfolio I was turned in, she pointed out to the researcher that her intuition about lack of time to gather material had been correct.

Interviewer: If you could change anything that has happened with the portfolios this year, what would it be and how would you change it?

Teacher: Well, if I had anything to change I would not have given the assignment at the quarter. I would have given it at the semester, because there would have been more material . . . I was concerned even when I assigned it. I thought they just don't have enough material yet. . . . And that is what happened, either they didn't pick anything at all, period, and didn't write anything, which meant they probably just plain didn't get finished, or they filled every one of them by digging and looking and trying to fit something that didn't really fit in. . . . Time is a really big factor.

The second time issue, that of time given to work on the portfolios in class, became apparent from classroom observations. The NCTM Goals Portfolio I was due after approximately 45 class meetings. However, approximately 36 minutes of class time, less than one class period, had been devoted to portfolio work and/or discussion. For about half of this time, the students arranged papers for their journals. During this 45 day period, the teacher had been observed on at least two occasions devoting an entire class period to going over homework problems and the teacher had reported spending at least two days giving each module test, which would have been about six class periods, or more, devoted to testing. When the researcher asked the teacher in a telephone conversation whether she thought the students had enough class time to work on portfolios, the teacher replied that she felt students didn't need to be given class time to work on everything she assigned. When focus students were asked "Do you feel that you had enough time to finish the assignment [the NCTM Goals Portfolio I]", the replies were:

Scott: Not in class. . . . I would rather do it out of class on my own time. 'Cuz in class when you get done I am already doing something else.

It's during school and you just don't want to start doing it then. You just want to do it when you feel like it.

Kristin: Uh huh [yes]. I have study hall right before math so I can get everything done.

Mandy: I didn't think that there was enough class time, really. 'Cuz, basically, our test took so long. . . . We were supposed to have time on Friday to work on it in class Friday, but our test took the whole period on Friday. [If I had more class time] I probably would of like talked [with other students] about [the portfolio] but, I don't know, maybe it's good just to do it on your own instead of getting other people's ideas in there.

Responses varied on this issue. One student did not want to work on the portfolio in class, another student had plenty of time in study hall, and another would have appreciated more class time.

The teacher never expressed to the researcher any concerns about the amount of class time allotted to portfolio work. However, she must have considered this issue because, near the end of the semester, she did allocate more time to the preparation and presentation of the NCTM Goals Portfolio II. Ten minutes were devoted to writing a reflection on the NCTM Goals Portfolio I, 25 minutes to the teacher giving directions, 89 minutes to the students actually working on the portfolio in class, and 25 minutes for the class presentations. During the entire semester, which consisted of approximately 90 class meetings, 185 minutes, or about three and a half class periods, were devoted to the portfolio. It cannot be determined whether the increased time spent on portfolios increased the quality of the second portfolios, but in the final interview, the focus students said that they found the class time for portfolio work valuable, and the final portfolios were of much better quality than the first portfolios. Perhaps the fact that there were more work samples to choose from at the end of the semester made it easier to compile more complete and better developed portfolios.

The teacher raised a third time issue. She felt pressured by lack of time to communicate with the students about the portfolios.

Interviewer: Now last year you had portfolio conferences with your kids? Are you thinking about doing that again?

Teacher: I'm thinking about it. I'm worried about . . . time. That's my biggest worry because when I did it last year I had a student teacher and I left the room and took the kids out one at a time and she was in here. And this year, I'm not going to have that. So there is going to be a problem with "how am I going to do that." Unless I just do it right in the room, but then everyone would be in here. But just do a short interview while the other kids are doing other work and that's maybe what I'll end up doing.

She disclosed that she felt pressured to "get through" more modules. Because of this, she said she may have poorly communicated her expectations to the students. As a result, she thought they could have misunderstood her directions, and turned in poor quality portfolios. Also, the teacher commented that she wanted to provide more feedback to the students, but time was a valuable commodity in her classroom. She wanted to talk to Scott about the incorrect solutions to open-ended problems he had selected for his portfolio and she had wanted to give the students suggestions for improving their portfolios. In a telephone conversation with the researcher, the teacher reported that she did not hand the NCTM Goals Portfolio I back to the students, but just gave them a slip of paper with their grade for each goal written on it. She said that she did not discuss the grades with the class at that time and also did not talk about her expectations. She said that the students would know that she was disappointed when they saw their poor scores. When the researcher asked her whether she planned to discuss with the students how they could improve their portfolios, she said she would like to, but may not have time.

As it turned out, the teacher re-assessed the portfolios and made suggestions for improvement of the NCTM Goals Portfolio I for the students to use in preparing the NCTM Goals Portfolio II. The suggestions were given to the students the week before

the second portfolio was due. The focus students expressed that the comments helped them in improving their portfolios. The teacher also spent about 25 minutes of class time giving directions for the portfolio and she gave them a handout with two additional requirements, a decorated folder and a personal history from each student. The last week of the semester during the students' portfolio presentations, the teacher asked the students questions about portfolio selections.

The fourth time-related issue was discussed by the teacher in the final interview.

Interviewer: What do you see as major issues in using portfolios?

Teacher: Time, and it will be a major issue and I only had nine [portfolios to grade]. . . . That's going to be an issue for getting other people to do them. And . . . if I had 30 to do (trails off).

With only nine students grading time was not an issue for her, but she believed it would be for larger classes. She expressed concern that some teachers may not use portfolios because of the grading time involved.

The time issue was multi-faceted. It was interwoven with other issues such as the importance of the portfolio and communication about the portfolios. In the beginning, classroom time was devoted to testing and homework, but not to the portfolios or to communication of expectations about the portfolios. It cannot be determined what impact this had on the quality of the portfolios or the experiences of the students. It was not possible to determine whether the lack of classroom time spent on the NCTM Goal Portfolio I was one direct cause of poor portfolio development or whether the lack of time spent on portfolios was interpreted by the students as portfolios lacking importance.

Value of the Portfolio

Another portfolio issue that arose in the classroom centered on their value. The issue at hand dealt with whether the students considered compiling the portfolio a worthwhile task. In the second interview after the first portfolios were assessed, the teacher said that the students were seeing the portfolio as "busy work."

They are not seeing the value of it as much. I think last year it was new and different and they had never done it before and it was interesting. And that to me is a little bit interesting because if portfolios become a standard form of assessment, is that the way kids are going to feel? "Oh, we gotta work on that stupid portfolio."

The teacher was afraid that students failing to value portfolios could be a problem for any teacher using them regularly in the classroom. She was particularly interested in how to solve the problem in her classroom before a second round of poor quality portfolios resulted. She discussed with the researcher several possible strategies.

To increase the value of the portfolios in the eyes of the students, one strategy the teacher employed was attaching grades. For some of the students, 50 points (the score awarded to the NCTM Goals Portfolio I) had not encouraged them to turn in a quality product, so the teacher increased the point value of the NCTM Goals Portfolio II to 100 points. However, she noted that some students did not care about the grade and that they wouldn't do a good job on the portfolio if they didn't think that it was important to do.

I hope the way that it is counted as a grade will help. But you know it is not a required class, and they could fail it and it won't hurt them, except for those who don't want to fail a class, which most of them do care about their grade.

The teacher was facing a dilemma because she hoped a grade would cause the students to value the portfolio and yet she knew that this strategy would not succeed with some of her students. In addition to increasing the number of points that the portfolios were

worth, she told the students that the portfolios and oral presentations would replace the semester exam. All three of the focus students told the researcher they liked this idea.

Another strategy the teacher utilized to help the students value the portfolio was to increase students' ownership of their own portfolios by having them show their portfolios to other students during the in-class presentations. She also instructed them to decorate the binder that held the selections and required them to write a personal description of themselves to include in the NCTM Goals Portfolio II.

It was not possible to assess the value the students placed on the portfolios they compiled in this mathematics class. The only evidence of valuing that the researcher ascertained was that on the final day of the study all of the students said that they would recommend using portfolios to the school's mathematics curriculum committee (See page 139 for their reasons.).

Communication and the Portfolio

Communication between the teacher and students and between students concerning the portfolios were found to be issues. The teacher realized that communication was an issue after several students turned in poor or incomplete NCTM Goals Portfolios at the end of the first quarter. She thought they had misunderstood her directions. She also said that she wished she had more time to talk to students about their portfolios on an individual basis or to conduct interviews. The researcher noted the lack of time spent in class giving directions for the first portfolio. The teacher attempted to address this issue the week before the NCTM Goals Portfolio II was due by giving more directions in class, answering questions, showing the students a portfolio selection and justification that met her expectations, and by giving them written feedback. The focus students appreciated the comments and said they used them, but they reported that the student example shown to them in class was not

valuable. The teacher markedly increased both her written and oral communication with the students relative to the portfolios during the last week of the semester.

The teacher encouraged students to share ideas with one another about the portfolios during their work times. However, she told the researcher that no one discussed the portfolios during the partial class period they were to work on the NCTM Goals Portfolio I and the researcher observed no student interaction related to the portfolio during the work days given before the NCTM Goals Portfolio II was due. The only student interactions during those days were: (a) a discussion of the upcoming pep rally among several students, (b) a discussion between two students about a recent trip, and (c) a discussion between two students comparing clip-art on the computer to use for decorating their portfolio folders.

Although the teacher gave oral directions in class for the portfolio and encouraged students to ask questions, only nineteen questions relating to the portfolio were asked during the four work days in January. Twelve of those questions were focused on the due date, the amount of time they would have to complete the portfolios, the number of points possible for the portfolio, and the organization of the portfolio, such as how to attach the justification to the selection. Seven of the questions related to the actual content or quality of the portfolio. Some of these content/quality questions were: (a) how to present the portfolios in class, (b) what mathematical reasoning meant, and (c) could a selection be just one problem from a test or assignment. Nine of the questions were asked by the two male students, with seven of those from the new male student. Ten were from four of the seven female students. Three students asked no questions. Scott, Kristin, and Mandy, the focus students, asked 2, 3, and 3 questions, respectively, over the course of the four days.

Communication about the portfolios between teacher and students was limited until the last week before the second portfolio was due. Even when time was allotted

for student questions, few of those questions related to the actual content or quality of work to be placed in the portfolio. On the days of the researcher's visits, student interaction, regarding the portfolio, was non-existent.

Curriculum and the Portfolio

The mathematics curriculum used in this classroom was integrated and innovative, as noted earlier. The teacher employed varying instructional methods and activities involving discovery, technology, group work, and research projects. Many of the problems in the modules were based on real-world applications. The teacher required written explanations for students' solutions to problems, written summaries of the modules they completed, and also responses to journal questions that often focused upon their thoughts, attitudes, and feelings. However, the teacher was still concerned that the students would not have enough variety of material from which to make portfolio selections.

Interviewer: Have you found yourself doing extra things with the class so that students will have portfolio selections?

Teacher: Yeah. I gave them those two open-ended problems [See Appendix C for the Drug Problem and the Grasshopper Problem]. . . . Last year . . . we did more open-ended [problems]. We did open-ended at the beginning, at the middle, and so they had a bunch of problems and they did use those problems a lot. . . . The modules that we have covered [this year] . . . were fairly traditional really, truly. The module we just covered, they were finding the zeroes of the one degree and then the two degree and then the three degree and, not knocking it, but that is not a lot of variety. Like they were talking about the Skittles [module] today. Those modules had such variety.

The teacher, then, had given the students open-ended problems before the first portfolio was due to give them additional potential selections. She repeated this again just before the NCTM Goals Portfolio II was due giving the students three open-ended problems to solve. (See Appendix C for the 3 problems.). However, two of these

were the same problems she had given them before the first portfolio was due. She thought they had provided poor solutions and now wanted them to improve upon their solutions.

At the end of the study, the teacher was still convinced that using alternative assessments, such as portfolios, was enhanced by an innovative curriculum.

Interviewer: Would you recommend the use of portfolios to other teachers of mathematics?

Teacher: I think if they are . . . trying to implement the Standards [Curriculum Standards] in their classroom and they want to evaluate them, these [the portfolios] are probably the best way they are going to find right now to evaluate how things are really going. 'Cuz I don't think there is really any other way. If they're not doing any of that kind of stuff, this [using portfolios] would be hard to do. So if you are not doing journaling in your class, you are not doing open-ended questions, and you are not doing a lot of problem solving, research projects, . . . I wouldn't recommend it to them, but if they are trying to implement the Standards and they really want to show what the kids are doing, I would recommend them.

Two of the focus students shared the teacher's opinion about the dependence of the portfolios upon the curriculum. While reviewing her portfolio with the researcher, Kristin pointed out that portfolios would be difficult for the students to compile in some mathematics classes.

Interviewer: Do you think that a portfolio could show that a student values mathematics?

Kristin: Yeah. . . . (long pause as she looks at hers) . . . I think that it would be hard in a traditional class because most of what you do is just working problems, but if you did more variety of different types of math, I think you could pick an item that shows you value mathematics.

Kristin selected a journal entry comparing her experiences in a geometry class to her experiences in a SIMMS mathematics class. As she read over what she wrote in the journal entry, she came to the realization of how she valued SIMMS mathematics.

When I was looking for a piece that showed I valued mathematics [mathematics] no other piece said that as much as this one. When I was writing this I didn't realize that math was so much better here[her present school]. I also didn't know just how much I do value math. This piece helped me to see that math is important. Math is different in different areas and I value the math I am taught here much more.

Mandy expressed a similar opinion about portfolios and the curriculum. She said that she was able to find a selection that showed she valued mathematics because, in SIMMS mathematics, students are shown where mathematics applications are useful. Her definition of valuing was usefulness. Kristin and Mandy both felt that if they had been in a mathematics class, different from SIMMS, then they probably would have had a difficult time showing how they valued mathematics through their work in the classroom.

Equity in Assessment and the Portfolio

Another issue that came to light during the study was whether portfolios were an equitable assessment for all students. Two opposing sides were expressed. After the NCTM Goals Portfolio I was turned in, Kristin, a focus student who was not normally motivated to do homework, said that the portfolio made her want to complete her homework so that she would have something that showed her ability, to place in her portfolio. Here was a student who admitted to not working very hard in school and also skipping school to avoid homework. Yet, she reported that the portfolio was motivating her to do more work in this class.

On the other hand, the teacher pointed out in the third interview that she was concerned about the equity of portfolio assessment for students who had problems communicating in writing.

Another thing that I have noticed is that Scott is really good in communicating his written work. . . . I thought other kids might have a good idea of what reasoning is, but they can't put it on paper. That is one thing about every one of those questions [justifications for the NCTM student goals], the kids who are

better at communicating written work, are better at the explanations. Like there is one person, Becky, that is in Chapter English [a tutoring program for students who need extra help]. And hers are real hard to understand . . . yet, I thought, does that mean she doesn't know what reasoning is? Or does it mean she can't put it down on paper? That is a disability, I don't know if that is a disability that she has, but I know there are people who have known disabilities of not being able to communicate. Although it [doing the portfolio] is forcing them to do that and I think that is one of the best things you can do. And it is making them think about it where they wouldn't think about it otherwise.

The teacher went on to suggest that a student like Becky might benefit from being interviewed. What the teacher had observed with communication, be it written or oral, could be a problem with portfolio assessment. She also noted that it was beneficial for students to practice communication and that the practice certainly would not hurt those students if their disabilities were taken into account.

Grading and the Portfolio

Grading was an issue discussed earlier in relationship to the issue of time. The teacher had said that time for grading was not an issue for her, with only nine students, but that it would be an issue for larger classes. However, she felt that portfolios were more worthwhile than other work products that she graded, such as notebooks. She suggested that a teacher might consider replacing notebooks with portfolios. Grading was also discussed earlier in relationship to the value of the portfolio with the teacher hoping to encourage more student effort by increasing the number of points she would award to the portfolio assignment. Another grading issue identified by the teacher dealt with how to grade the portfolios.

I still think portfolios are really hard to grade, and I'm not sure, except to get the kids to do them, how much value the grade is anyway. Telling a kid that you think what they think is their best work is a C. For me the grading part was really hard. Some things I could look at . . . effort or doing it or not doing it. [Those] were what I had to use for my criteria because I could not say to someone, "That's not valuing. What in the world are you talking about?" or "That's not a good example." Although on some of them I said you might have found a better example of problem solving. . . . I am trying real hard, but . . .

the grading has been real hard. I write, I scribble it out, and then I think, "Well, you know, I can't [grade it what way] just because that is not what I [think]." "Well, I'll give them (trails off)." Then, I am debating between 10's, 9's and 8's. I still have this, "What should I give them as a score?"

At the end of the semester, the teacher gave each student a score sheet for their NCTM Goals Portfolio II. On each sheet, the researcher observed a number of "scribbled out" and rewritten scores. An interesting comment from the interview excerpt was, "I'm not sure . . . how much value the grade is anyway." Throughout the study, the teacher assigned grades to motivate the students, but now she was saying that she didn't know what value the grade actually had.

Summary

In this research, which centered on students' perceptions of utilizing mathematics portfolios, the students reported personal benefits from their experiences with the portfolio and suggested that their teacher recommend portfolios to their school's mathematics curriculum committee. The implementation process was a learning experience for all participants, including the students, teacher, and the researcher. Although the focal point of the study was the students, the implementation of portfolios in this classroom and the teacher's perceptions raised some critical issues which could not be ignored in this report of the results. Implications and recommendations from these findings are discussed in Chapter 4.

CHAPTER 4 DISCUSSIONS, IMPLICATIONS, AND RECOMMENDATIONS

The National Council of Teachers of Mathematics (NCTM) has recommended changes in school mathematics curriculum, instruction, and assessment . In particular, three documents have been instrumental in spurring the mathematics education community to take action: the Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989), the Professional Standards for Teaching Mathematics (NCTM, 1991), and the Assessment Standards for School Mathematics (NCTM, 1995). As reported in Chapter 1, many educators in mathematics and other disciplines have advocated the utilization of portfolios with little research to justify this practice.

In this study, the researcher investigated mathematics portfolios from the perspective of high school students who created their own portfolios. In addition, the teacher's perspective was examined, as the teacher's role in the implementation of portfolios in this classroom was significant to the final results. The research question was: What are high school mathematics students' perceptions about portfolios as a tool for assessment, that is, for demonstrating their progress in fulfilling mathematics goals? The goals were: (a) students learn to value mathematics, (b) students become confident in their mathematical ability, (c) students become mathematical problem solvers, (d) students learn to communicate mathematically, and (e) students learn to reason mathematically (NCTM, 1989).

In brief summary, this study was conducted during the first semester of the 1995-96 school year in a small high school located in a rural community. Three students in a twelfth grade mathematics class were the subjects of the study. The class was using an integrated, innovative mathematics curriculum featuring real-world

applications of mathematics and relied heavily upon technology, such as graphing calculators and computers. Group work and investigation were routine classroom activities. The teacher was in her fourth year of teaching integrated mathematics and her second year of implementing portfolios. Some students were compiling portfolios for a second time, while others were new to this assessment method and integrated mathematics curriculum. Students were to select portfolio items that would specifically document their accomplishments relative to the five NCTM student goals. The students exercised freedom in making their own selections. Other assessment methods, such as paper-and-pencil testing, writing in mathematics, and journals, were employed by the teacher. The three focus students provided the major portion of student information. However, the other students were observed in the classroom and their written work was also examined to aid the researcher in interpreting the data.

Qualitative methods of data collection and analysis were utilized. The data collection methods were: open-ended questionnaires; individual, in-depth interviews; classroom observations; and examination of students' written work. Detailed classroom observation notes and field notes documenting all site visits were kept. For data analysis, the researcher used the method of constant comparison. Data from the sources listed were constantly compared helping to focus subsequent interviews and observations. The researcher also maintained a personal research journal for recording information and for reflecting, which assisted in data analysis.

In this concluding chapter, there are sections devoted to discussions and implications of the findings, limitations of the study, and recommendations for future practice.

Discussions and Implications

Interpretations of Goals and the Grading Predicament

At the beginning of the study and throughout the semester, interpretations of the NCTM goals varied from student to student. The constructivist theory supports the existence of variations in students' interpretations. Constructivist theory asserts that "students construct knowledge to 'fit' what they already know (or believe) about the world" (Stiff, Johnson, & Johnson, 1993, p. 7). The continuing variances can probably be attributed to lack of classroom communication. Students were never observed during class conferring among themselves about their interpretations of these goals. Also, according to the researcher's observation notes and to the teacher's own self-report, the teacher did not relate her own definitions to the students, except on one occasion. During the week before the NCTM Goals Portfolio II was due, one student received a written comment from the teacher that made the teacher's definition of mathematical communication evident. That comment directly altered the student's definition, as illustrated in her NCTM Goals Portfolio II. When the teacher encouraged the students to ask questions about compiling their NCTM Goals Portfolio II during a four day period allotted to portfolio work, only one of nineteen student questions related to the NCTM student goals. The new, non-focus student asked the teacher what mathematical reasoning meant and the teacher said she wanted him to formulate his own definition.

Varying interpretations of goals were also observed in an informal study of preservice elementary education students majoring or minoring in mathematics (Pokay & Tayeh, 1996). The instructors of a geometry class of thirty-six students required them to develop portfolios focusing on writing and reflection. At the end of the course,

the students compiled evaluation portfolios that "gave proof or evidence of (1) their problem-solving ability, (2) their confidence in their mathematics ability, (3) their determination to stick with a problem, (4) their most valuable experience in the class, and (5) an activity in which writing helped them to learn" (p. 309). In their portfolios, the students were also expected to include letters explaining each individual selection. Unlike the research study reported here, students in the Pokay and Tayeh study were not asked to define goals, like mathematical problem solving or confidence in mathematical ability, at the beginning of the study. Students just placed selections in their portfolios that would give evidence of the five goals previously listed. By examining the students' portfolio selections, Pokay and Tayeh noticed a variety of interpretations of the goals: "After reading students' responses, the instructors learned that students often attached their own meaning to such terms or concepts as problem solving" (p. 311). It was not apparent from Pokay and Tayeh's report whether the instructors made explicit to the students the meanings of problem solving or any of the goals that were to be demonstrated in their portfolios. Therefore, it is not evident whether lack of communication in the classroom caused the variance in interpretations. The course, however, focused on problem-solving activities, open-ended problems, and working cooperatively in groups indicating that a definition for problem solving was at least inferred by the curricular and instructional decisions of the instructors.

When the teacher in this study attempted to grade the portfolios at the end of the semester, the variances in interpretations of the goals were problematic. She reported agonizing over assigning grades to the students' portfolio selections, because she did not want to impose her meanings on the students. In the end, she resorted to grading on her perception of the effort students put forth in compiling their portfolios. She did make written comments to the students suggesting that they could have made more appropriate selections, but it is not apparent whether that meant a selection that better fit

her definition, a selection that better fit the student's definition, or a selection that better demonstrated the student's strength in that area. Similar difficulties in scoring portfolios were reported in Vermont (Koretz et al., 1992). The plan in Vermont was to score students' portfolios and use the scores to compare students, schools, and districts across the state. However, the selected items were so varied that scoring the portfolios was practically impossible and, as a result, no reasonable comparisons of students, schools, or districts could be accomplished.

As Paulson and Paulson (1994) were striving to develop a model for assessing portfolios, they concluded that there are two different orientations for portfolios. Both of these orientations were observed in the study reported here. Their research involved two large-scale portfolio projects, one for the Wyoming, Michigan School District and the other for schools in Atlanta, Georgia. As they studied these two portfolio projects, Paulson and Paulson realized that the projects were using two opposing views of portfolios, the positivist and the constructivist.

The positivist approach puts a premium on the selection of items that reflect outside standards and interest.

The constructivist approach puts a premium on the selection of items that reflect learning from the student's perspective. (Paulson & Paulson, 1994, p. 7)

The Atlanta project "prescribed what materials students would generate for their portfolios" (p. 5), a positivist view. On the other hand, the Wyoming project philosophy was constructivist: "Part of the learning for the student was to interpret the goal and to make it operational" (p. 6).

In the study reported here, both portfolio orientations were used. The teacher made a conscious decision to allow her students to define the goals (the constructivist approach), but she then wanted to grade the portfolios and eventually use portfolios in

evaluating curriculum (the positivist approach). The teacher's grading dilemma was probably the result of switching from a constructivist approach to a positivist approach.

The teacher's grading predicament, resulting from a conflict between the two approaches for portfolio assessment, illuminates a key issue in implementing portfolios. A decision must be made before implementation: (a) Will the purpose of the portfolios be to compare students or schools? or (b) Will the portfolios serve as an information source for the teacher and a learning tool with students defining goals or standards as part of the process of assembling their portfolios? The Assessment Standards (NCTM, 1995) affirms that assessment should match the purpose for which it is being used. If portfolios are to meet this guideline, then deciding upon the purpose before implementation is essential.

One might question a teacher's practice of allowing students to define their own goals. If the teacher clearly presents interpretations of particular goals, then students can more easily try to demonstrate fulfillment of those goals. However, if the teacher defines goals explicitly, would the students need to think as critically as they create their portfolios? Students in this study reported having to "really think hard" about the meanings of the goals and also reported enjoying this process. If the teacher had provided clear-cut examples of fulfillment of each goal, would the portfolios have been as valuable in the respect of provoking students' critical thinking? Another issue, raised by Case (1994), is: "Once standards are defined by an outside authority, collaboration is minimized and the importance of the student's own goals and assessment of learning diminishes" (p. 46). Case contends that the most important benefits of portfolios are allowing students to show what they can do and giving them control in demonstrating their strengths. She recognizes that there is a conflict between the uses of portfolios and that "If there is a way to resolve the dichotomy between assessing achievement and personal goal-setting, it is not an easy one" (p. 47).

Teacher Implementation of Portfolios

Implementation of portfolios, even for a teacher who has undertaken other reforms, is not an easy process. Recent research on alternative assessments shows that other teachers encountered various difficulties in implementing these assessments, even when implementation was carefully planned (Koretz et al., 1992; Leitner & Trevisan, 1993; Flexer & Gerstner, 1993; Aschbacher, 1992). The issues of time and difficulty in assigning grades to portfolios, raised by the teacher in this study, were common problems with the teachers in the four studies aforementioned.

Near the middle of the semester of this study, some students voiced negative opinions about the portfolios, according to the teacher, and indicated that compiling them was busy work. Walen (1993) and Ivey (1994) found that students can affect the teacher's implementation of reform in the classroom. In the research reported here, students' opinions and lack of effort on the NCTM Goals Portfolio I influenced the teacher and caused her to change her implementation plan. She increased class work time for the portfolios, added requirements, gave more directions, and replaced the semester exam with the portfolio. However, the researcher never observed her discussing with the students the value of compiling portfolios or any of her reasons for the changes she made, such as giving them more work time or replacing the semester exam with the portfolio. Clark and Yinger (1980) note:

No matter how elaborate and complete a plan may be, it cannot be carried out successfully unless the students are brought rather fully into the knowledge of what to do and how to do it, and brought to a commitment to cooperation in the process . . . but communication of plans to students is almost never addressed. (pp. 21-22)

In this classroom, it appeared that the students were unaware of the intentions of their teacher relative to the portfolios. Some of the problems that arose may have been alleviated through more meaningful communication about the portfolios. It was the

desire of this teacher to allow her students freedom in interpreting the goals they were to demonstrate in their portfolios, but she could have discussed other aspects of the portfolio, such as its value, with them.

The teacher in this study cited lack of class time as one reason for not communicating more with her students. However, she may not have thoroughly planned the portfolio implementation, because of other demands on her time. Fullan (1991) contends that "for most teachers daily demands crowd out serious sustained improvements" (p. 118). This teacher was the only teacher in her school utilizing an innovative, integrated mathematics course. In addition, she was serving on a curriculum committee and felt compelled to contribute information about portfolios by implementing them in her mathematics classroom. Demands on her time inside and outside the classroom were high. Despite her lack of time, the teacher did put into action several strategies for increasing the quality of the portfolios and, as a result, she felt that the final portfolios were of much better quality than the first portfolios had been. Implementing portfolios caused the teacher to sustain change in her classroom until the desired results were obtained.

Another issue that arose during the portfolio implementation was the teachers' assessment priorities. The teacher did not appear to make portfolio assessment a priority in her classroom until the last week of the semester. The due date of the NCTM Goals Portfolio I was postponed because she chose to administer a module test. However, at the end of the semester she spent more time on the portfolios and replaced the semester exam with a portfolio presentation. She wanted to implement the portfolios and report the results to her curriculum committee, but she also felt pressured to "cover" a certain portion of the mathematics curriculum. Also, she may not have felt completely comfortable with the NCTM Goals Portfolio since she had previously used a portfolio with a different format.

There are several possible explanations for the higher priority she appeared to place upon the portfolios during the last week of the study. One reason may have been her promise to the researcher that she would have the students complete the portfolios and she wanted the final portfolios to "look good." The mathematics curriculum committee did not meet from the spring of 1995 until the end of the first quarter in the fall of 1995. With the resumption of these meetings, she may have begun to think again about her initial plan for the portfolios. She also may have become more comfortable with the new format of the portfolios by the end of the semester and she may have realized the valuable information that she was gaining by examining the students' portfolios. For whatever reasons, the teacher did change her priorities during the semester relative to the portfolio in her classroom.

Fullan contends, "Good change processes that foster sustained professional development over one's career and lead to student benefits may be one of the few sources of revitalization and satisfaction left for teachers" (1991, p. 131). The teacher commented informally to the researcher that she was glad to have the opportunity to participate in a portfolio research study. Her reason for feeling this way was that someone from the outside was giving her an additional "push" to continue to expand and grow as a teacher. Implementing change within the context of a support system, despite the problems, may be beneficial to the morale of teachers.

Benefits of Portfolios for Teachers

From the process of implementing portfolios and from the portfolio products, this teacher gained information about her students that she may not have been able to gain using other methods. This included personal information about them as people, plus insights into their thought processes. Formal studies and informal reports about using alternative assessments, including portfolios, have shown similar results (Kulm,

1993; Aschbacher, 1992; Koretz et al., 1992; Borasi & Rose, 1989; Voss, 1992; Chiseri-Strater, 1992; and Pokay & Tayeh, 1996). Pokay and Tayeh (1996) comment, about their informal research using mathematics portfolios with preservice elementary teachers, "Their [students'] work revealed insights about . . . students that would not have been gained through more traditional methods of evaluation" (p. 309). The teacher in the study reported here saw students' levels of confidence through examining the contents of their portfolios.

In this study, the teacher believed that her school could not assess some of their new mathematics goals, such as valuing mathematics and confidence in mathematical ability, with methods such as standardized testing. The teacher envisioned the portfolio as part of the solution to her and her school's new assessment needs. The NCTM Assessment Standards (1995) recommends that multiple sources of assessment be used. For example, in this school, then, the committee could decide to use standardized tests for showing competency in skills, portfolios for critical thinking, and journal writings for student affect. Portfolios could be one component in the school's whole assessment plan.

As this teacher learned more about her students through their portfolios, she became excited. King, Warren, and Peart (1988), in a study of 6,000 high school teachers, found that two of the most satisfying events reported by teachers were becoming acquainted with and establishing rapport with their students. These teachers also reported enjoyment in observing students as they finally understand a concept. If portfolios assist teachers in knowing their students as people and aid them also in observing their students' thinking and understanding, then that may motivate teachers and give them added job satisfaction. Portfolios may be a vehicle for both teacher and student motivation.

Student Motivation and the Portfolio

Kristin, a focus student who was not motivated by grades, used the portfolio as her motivation to complete homework. The Assessment Standards (1995) promotes assessments that are equitable for all students. Kristin was not interested in completing homework for its own sake, but she wanted her portfolio to portray a positive picture of herself, so she finished her homework to place in the portfolio. She also liked creating her own portfolio, because she could self-select items and demonstrate her strengths. She reported that this gave her confidence. If a variety of assessment methods are used, then each student should find at least one type in which they can participate positively. Portfolios are not a panacea assessment, as seen by this teacher's concerns about students who could not write well, but they were effective for one unmotivated student.

Deci and Ryan (1992) contend that intrinsic motivation is fostered by allowing students self-determination. Kristin may have been intrinsically motivated by the freedom of choice given to her in compiling a portfolio. Most school assessments are graded, with the grade being the reward or extrinsic motivation to which the students are to respond. The class involved in this study was no different. On numerous occasions, the teacher confided to the researcher that her students would not do any assignments, even journals or portfolios, unless she graded their work. However, grades did not motivate Kristin. She reported that she enjoyed selecting portfolio items that made her feel good about herself.

The authors of the Curriculum Standards (1989) claim that "An exclusive reliance on a single type of assessment can frustrate students, diminish their self-confidence, and make them feel anxious about, or antagonistic toward, mathematics" (p. 202). By incorporating portfolios into a broader assessment plan, students who

have previously been unsuccessful in assessment situations may find portfolios to be a method for demonstrating their strengths. They may then gain self-confidence and develop a more positive attitude towards mathematics. In addition, portfolios may be a new technique to use for motivating students in the mathematics classroom and, as a result, increase student learning.

Student Attitude and the Portfolio

Mandy, a focus student, was very hesitant throughout the semester about using portfolios. She was new to innovative, integrated mathematics and to using portfolios, but by the end of the semester she expressed a positive attitude about her experiences with portfolios. Micheal, a non-focus student, said he personally gained by thinking about the student goals and selecting portfolio items. Micheal and Mandy both recommended portfolios to the mathematics curriculum committee. These were only two students who entered an innovative mathematics program and accepted changes in assessment, but their final attitudes demonstrate that students can accept reforms in mathematics and in assessment. A similar finding is reported by Lesnak (1989). In a study of college students and the implementation of writing in a mathematics course, Lesnak observed that some of the students were reluctant and even "hostile" about having to write in a mathematics course, but at the end of the semester all fifty-two of the students made positive comments, even eight students who failed the course.

Finding that students will accept the use of portfolios, especially students who are experiencing significant changes in their mathematics course, is informative for educational practice. Students must be willing to participate in the assessment in order for it to be successful. Walen (1993) and Ivey (1994) both determined that students played a critical role in the success of changes implemented by teachers in mathematics classrooms.

Students Engage in Critical Thinking

Students reported that they perceived using critical thinking as they defined the NCTM student goals and created their portfolios to document these goals. This finding validated results of other researchers and reports from classroom teachers (Powell & Lopez, 1989; Borasi & Rose, 1989; Katims, Nash, & Tocci, 1992), where students also reported thinking critically when using writing in mathematics and performance assessments. Proponents of portfolios have claimed that portfolios are instruction and assessment together (Graves, 1992; Paulson, Paulson, & Meyer, 1991). If students engage in critical thinking while developing their own portfolios, then portfolios would be instructional tools. The portfolio may not increase students mathematical content knowledge, but it may benefit them in other areas such as mathematical communication. In this study, two students specifically reported increasing their communication skills as a result of developing a portfolio. The Assessment Standards (1995) states that "Although assessment is done for a variety of reasons, its main goal is to advance student's learning and inform teachers as they make instructional decisions" (p. 13). Several students in this study reported learning as a result of their portfolio experiences. Therefore, portfolios would meet "The Learning Standard," one of the six standards for mathematics assessment (NCTM, 1995). (See page 19 for a discussion of this standard.)

Students and Assessment Reform

The students in this study recommended portfolios as an assessment method to their school's mathematics curriculum committee. They also provided thoughtful responses to questions about the portfolio and made suggestions for alternative ways to assess some of the NCTM student goals. These students were taking part in

assessment reform. Students went beyond just receiving feedback from the teacher on their portfolio products and provided the teacher with information about their experiences with the portfolios. This participation is supported by "The Openness Standard," presented in the Assessment Standards (NCTM, 1995). (See page 20 for a discussion of this standard.)

What happened in this research study shows that students are willing to make, and capable of making, thoughtful comments about classroom practices. The literature shows that students are seldom asked for their thoughts about education. Fullan (1991) remarks: "We hardly know anything about what students think about educational change because no one ever asks them" (p. 182). McLeod (1992) also notes that little is known of student beliefs about mathematics instruction. In this study, students experienced a new assessment method and were then asked how the experience personally affected them. Even though there were only nine student participants with three focus students, what they said makes a contribution to the almost non-existent body of knowledge on students' perceptions about assessment.

Fullan notes that "Effective change in schools involves just as much cognitive and behavioral change on the part of students as it does for anyone else" (p. 189). Developing a portfolio requires a much higher level of participation by a student than just blackening in dots on a standardized achievement test. Students can randomly fill in the dots, but they cannot randomly complete a portfolio. Also, Asturias (1994) notes that "As students begin to work on portfolios, they take an active role and assume some responsibility in their own assessment" (p. 698). It would only seem reasonable that if educators want students to participate in changes, such as new assessment methods requiring a high level of student effort and involvement, then the students need to feel they are taking part in assessment decisions.

Limitations of the Study

This study was conducted in one classroom and focused upon three twelfth grade students and their teacher. The mathematics curriculum was innovative and integrated and two of the focus students had experienced this curriculum, a variety of instructional methods, and alternative assessments for more than a year. The portfolios were very specific in that students needed to demonstrate the five NCTM student goals of valuing mathematics, confidence in mathematical ability, mathematical problem solving, mathematical communication, and mathematical reasoning. The findings of this study cannot be indiscriminately applied to other settings, students, or teachers.

The teacher allowed the students to form their own interpretations of the NCTM student goals. Therefore, definitive answers as to how well each student actually demonstrated each goal cannot be provided. Students' interpretations of the goals were, in most cases, not as broad as was the intent of the NCTM.

During the study, the researcher visited the site eleven times. It was not feasible to attend every class meeting and, therefore, discussions relevant to the portfolio could have occurred of which the researcher was unaware. The researcher talked with the teacher at least once per week, but the teacher may not have remembered every incident that occurred relative to the portfolios. In addition, the focus students were asked whether they worked with other students on their portfolios. Even though they reported they had not, they may have forgotten discussions with other students that occurred outside the classroom.

There is always the possibility that the researcher had some effect upon the participants being observed and interviewed. However, the researcher assumed an observer stance during classroom observations and only twice did the teacher call

attention to the researcher during observations. The students appeared to ignore the researcher during the classroom visits. This particular classroom of students, except for the two new students, had been observed every year for the past three years by SIMMS staff, because this was a pilot class for implementing these curriculum materials. Having a visitor in this classroom was not an unusual event. The teacher also relayed to the researcher in informal conversation that teachers from other schools had visited this class to see "SIMMS in action." Certainly, in the interviews the students could have falsified information, but they had nothing to gain. The students relinquished three study halls each to talk with the researcher, even though they had busy school schedules, and they appeared to be genuinely interested in discussing their experiences.

Even though a variety of data collection methods were employed, the researcher was the primary data collection instrument. As the study progressed, the researcher had to make decisions about patterns that were emerging in order to focus further data collection, such as observations and interviews. The researcher kept a journal to record decisions and dates of events, and to reflect upon the events that took place.

Recommendations for Practice

In this study, the teacher initially asked her students to provide their own definitions for the NCTM student goals. As the semester progressed, the students compiled their portfolios guided by their own definitions. The teacher did not attempt to communicate her ideas or the NCTM definitions for these goals to her students. Therefore, the students exhibited very little change in their interpretations of the five goals. The teacher was unable to accomplish a satisfactory assessment of the students'

progress towards fulfilling these goals because of the variances in their definitions and the fact that their definitions did not align with those intended by NCTM.

Asking the students to define the goals for themselves in the beginning allowed the students to think deeply and struggle with the meanings. This is a valuable experience for students because they must actively participate when formulating and clarifying their definitions. However, a teacher may experience more success in evaluating the final portfolios by employing several strategies. After the students initially define the goals, the teacher could, on a regular basis, model the goals during regular lessons or by designing special classroom activities. The teacher could also make a conscious effort to discuss particularly good examples of activities which meet the goals with the students as they occur in class. For example, a particular lesson could focus on organizing data in charts or graphs. At the end of the lesson, the teacher could focus a discussion on this activity in light of the NCTM goal of mathematical communication. Illuminating the NCTM goals would not need to expend valuable class time, but could be integrated into existing lessons.

A teacher could use student portfolio selections as a focal point for engaging students in classroom discussions. For example, several student selections which illustrate mathematical problem solving could be compared and discussed to determine which ones might best demonstrate a student's ability in that area. As students continue to develop and refine their portfolios to demonstrate their abilities, the students could also be refining their definitions for the goals to be demonstrated in the portfolio. The students in this study found redefining the goals tedious, but that could have been avoided by having the students write definitions only at the beginning and the end of the year, but discuss their changing thoughts throughout the year.

The duration of this research study was only one half of a school year. This length of time may not have been adequate for the students to define and refine their

definitions for the five NCTM student goals. It may have been more appropriate for the students to produce a showcase portfolio at the end of an entire school year rather than at the end of one semester.

In this study, another perspective of the time factor may have been revealed. The teacher attempted to implement portfolios as a measure of all five of the NCTM student goals. A more successful approach may have been to implement this type of portfolio in smaller increments. A possible option would be to focus upon just one goal, such as mathematical communication, for an entire semester or year and then the following year or semester, focus on an additional goal. The teacher could be very deliberate in planning activities and classroom discussions that illuminated the goal of interest. At the end of several semesters by phasing the goals in at specific intervals, the teacher could eventually employ a portfolio that was to exemplify the students' abilities in all five of the areas recommended by the NCTM. In the particular school where this study took place, the teachers could plan to collaborate in the implementation of the mathematics portfolios. Each teacher could be responsible for focusing on a particular goal or goals. Fullan points out that "effective change takes time" (1991, p. 106). Teachers who implement portfolios must make a commitment to spend several years in the process.

The teacher in this study spent little time discussing with her students her expectations relative to the portfolios. For example, she was concerned that students were not "seeing" the value of compiling portfolios. Teachers, preservice and inservice, need guidance in developing methods to communicate their expectations effectively to students, especially about new curriculum, instructional techniques, and assessment methods. In a report of an informal study of performance assessment in mathematics, Shannon and Zawojewski (1995) state that "Just because teachers changed their expectations for students in class did not mean that the students shared in

the 'new rules of the game'" (p. 753). If teachers do not communicate their expectations to the students, then how can they expect the students to know "how to play?" Shannon and Zawojewski also report that "explicit instruction about the goals and criteria for self-assessment of all their [students'] work helps students compile a portfolio" (p. 757). This was also the case in this study, where the teacher felt that the students produced better quality portfolios as a result of her communicating more with them about her expectations for their work. However, more communication may have produced even better results.

In the Professional Standards for Teaching Mathematics (1991), three of the six teaching standards focus on guiding mathematics teachers in becoming more effective in classroom communication: "The teacher's role in discourse" (p. 35), "Students' role in discourse" (p. 45), and "Tools for enhancing discourse" (p. 52). Teachers need to learn to ask questions that facilitate discussions, involve all students, and also result in dialogues among students. This type of discourse would certainly have aided the implementation of portfolios in the classroom studied here. Also, portfolios could serve as a focal point for student discussions, which did not occur in this classroom. The students did not discuss the portfolios among themselves. The teacher needed methods for facilitating discussion between students for the purpose of improvement of the portfolio experience for the students.

As evidenced by the data collected, students did not discuss their portfolios with other students during the semester. However, at the end of the semester, the portfolios served as a vehicle for the students to use for participating in decisions about assessment. The students shared their recommendations about the use of portfolios at their school with other students, the teacher, and the researcher. Since portfolios require personal involvement by students, students must be motivated to complete them. Allowing them to voice their approval or disapproval of some modes of

assessment may help them sustain the effort involved in performance assessments, such as portfolios.

Teachers need to be aware that change is not easily accomplished. However, if they are willing to alter their original plans, it is possible to achieve results that meet their expectations as illustrated by the experiences of the teacher in this study. One must remember that "Change is a process, not an event" (Fullan, 1991, p. 130). It is very unlikely that a teacher can implement portfolios and, from that day on, never have to reflect on the portfolio process or make any adjustments to the process. "[Change] requires individual implementers to work out their own meaning" (Fullan, 1991, p. 106). Teachers make adjustments constantly throughout their teaching day and implementing a new assessment form is no different. The teacher in this study made qualitative adjustments in her plans for the portfolio as she confronted the daily dilemmas of the classroom.

In addition, discussions with the researcher allowed the teacher to develop more successful strategies for implementing the portfolios. This teacher never mentioned discussing her concerns with other teachers, but she did discuss her problems and ideas for solving those problems regularly throughout the semester with the researcher. Lortie (1975) found that teachers are often isolated and do not have a forum for discussing issues with other teachers. In this study, the researcher became a sounding board for the teacher. Since the beginning of the SIMMS Project in 1992, teachers using this curriculum have been provided with the opportunity to meet with other SIMMS teachers several times during the year. The teacher in this study took advantage of these meetings, but it still appeared that additional outside help, in the form of a researcher who would listen to her problems, was beneficial to her. Mentoring, even for an experienced teacher, appeared to have been a key factor for spurring this teacher on as a difficult transition in alternative assessment practices was

being implemented. Mentoring relationships are sometimes established between experienced and novice teachers for the purpose of aiding the novice. These types of relationships should be extended to include pairing of experienced teachers who are implementing reform in their classrooms so that these teachers can share their problems and solutions to those problems. Mentoring could also include partnerships between university faculty and practicing teachers to the benefit of both parties. University faculty could stay abreast with the current influences upon public school students and the teacher could be informed of new reform issues and methods. Collaboration between both groups would benefit all involved and improve student learning.

Students in this study reported thinking critically about the definitions of the NCTM student goals. They also appreciated the opportunity to freely select items that portrayed their strengths as learners. The teacher reported gaining information she deemed valuable. As a result of these reports from the students and the teacher, it appeared that the real value of portfolios is their use as an information source for the teacher and a learning tool for the students. Other forms of assessment can be used for the purposes of comparing students or schools, but portfolios can afford students control over at least one part of their assessment. With the comparison paradigm removed, teachers will feel less compelled to grade the portfolios on technical quality. They can devise grading schemes for the portfolio that might include awarding credit for completing the project rather than "grading" on how well a student demonstrates their expertise in a particular area. However, it should be made clear to the student that these points are completion points and that if there are mathematical errors or issues that need resolution, the teacher needs to address them. There may also be other ways to motivate students to complete portfolios without awarding grades. It might be possible that students would complete portfolios to show to peers, other teachers, parents, or administrators rather than completing them for grades.

The implementation of portfolios is a complex and ongoing process. Portfolios can make tremendous contributions to the teacher's knowledge about the students. Portfolios have the potential to motivate students and teachers. They are not a panacea for all that ails assessment, but their potential as an instructional tool and assessment method cannot be ignored.

Recommendations for Further Research

Further research needs to be conducted on portfolios in the mathematics classroom. Compiling portfolios and assessing both the product and the process involve sustained effort from students and teachers. The benefits of this assessment tool must outweigh the costs to all of the participants. During the semester of this study, the teacher and students expressed that their experiences with portfolios were valuable. However, educators need to know what happens when portfolios are used for more than one year or possibly throughout the school career of a student. Several students in this study reported that working on the portfolios was tedious. Will developing portfolios just become a meaningless task that must be completed by students and assessed by teachers? Or will the portfolios give students and teachers a sense of purpose and allow for continuity from year to year? Other studies need to be conducted over time where a variety of assessments, including portfolios, are utilized.

Are portfolios beneficial for unmotivated students in general or was Kristin just an oddity? A diverse population of students need to be engaged in studies of mathematics portfolios. Students who struggle in school and do poorly on paper-and-pencil tests may benefit from compiling portfolios. However, these students could also be overwhelmed by the freedom of making their own selections and could struggle even more with this assessment method than they had with other methods. In addition,

recall this teacher's concern about students with disabilities in the area of written communication.

In regards to using portfolios in the classroom, what teacher and student activities and/or actions facilitate or hinder the implementation process? If there had been more classroom communication, would the implementation process have been smoother? Would classroom activities, such as modeling by the teacher or more focused classroom discussions, help the students to refine their own definitions of the five NCTM goals so that they would be more aligned with the intent of NCTM?

What is the influence of the student on the teacher and the implementation process? How can the student be encouraged to participate more positively in the process? What factors help students to accept change whether it is to a different curriculum, a new instructional method, or an alternative assessment form? These all seem to be key factors that need further investigation.

Research is also needed in the area of classroom communication. How can teachers better communicate their expectations to students? What can teachers do to facilitate classroom dialogues between teacher and student and between students? How can pre-service and practicing teachers be mentored in developing better communication skills in the classroom? Is collaboration between university faculty and experienced teachers a worthwhile model to pursue?

Just as portfolios require sustained effort and active involvement, so will the research needed to investigate their effects. Long-term research projects, involving committed researchers working collaboratively in the field with classroom teachers, need to be undertaken to resolve many of the questions surrounding the use of mathematics portfolios and similar alternative assessments.

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APPENDICES

APPENDIX A

Study Documents

Time Line of the Study

July, 1995:

- teacher agrees to participate in the study;
- researcher gives the teacher the proposal to read.

August 2, 1995:

- researcher meets with teacher to finalize plans, negotiate the portfolio structure and grading scheme;
- researcher and teacher discuss plans for delivery to teacher and return to researcher of student documents.

First two weeks of semester:

- teacher signs permission and agreement forms;
- teacher sends home student and parent permission forms.

First month of semester:

- teacher administers NCTM Goals Questionnaire;
- teacher introduces portfolio assessment to students;
- researcher completes first three classroom observations;
- researcher conducts first interview of teacher;
- students begin on portfolios (teacher-directed);
- researcher and teacher identify focus students;
- researcher conducts first interviews of focus students;
- researcher maintains weekly contact by phone;
- researcher begins analysis of student data.

Duration of semester:

- students continue portfolio selections negotiated;
- researcher continues weekly contact;
- researcher continues analysis of data;
- researcher continues ongoing literature review.

Mid-semester:

- teacher collects NCTM Goals Portfolio I ;
- researcher conducts second interviews of focus students;
- researcher conducts second interview of teacher;
- researcher completes more observations;
- researcher maintains weekly contact by phone.

Last month of semester:

- researcher completes observations;
- teacher collects NCTM Goals Portfolio II collected;
- researcher conducts third interviews of focus students;
- researcher conducts third interview of teacher;
- teacher administers NCTM Goals Questionnaire;
- researcher continues analysis of data.

Spring, 1996:

- researcher completes final analysis of data and writing of the final document.

Summary of Classroom Observations and/or Class Time Spent on Portfolios

Table 3: Classroom observations and time spent on portfolios

Date	Time spent on portfolios	Observation conducted?
September 6, 1995	15 minutes: portfolio reflection	Yes
September 26, 1995	0 minutes spent on portfolios	Yes
October 24, 1995	1 minute: NCTM goals portfolio guideline distributed to students	Yes
November 1, 1995	20 minutes: student work time	No - canceled by weather
Portfolios due November 3, 1995	Total minutes spent before due date: 36 minutes	
November 15, 1995	0 minutes spent on portfolios	Yes
November 30, 1995	0 minutes spent on portfolios	Yes
January 2, 1996	10 minutes: reflection sheet on last portfolios	Yes
January 3, 1996	23 minutes: directions & examples given by teacher	Yes
January 4, 1996	39 minutes: student work time with individual questions	Yes
January 5, 1996	52 minutes: 2 minutes of teacher directions, 50 minutes of student work time	Yes
Portfolios due January 8, 1996	Total minutes spent since last due date: 124 minutes	Total minutes spent on portfolios this semester: 160 minutes
January 12, 1996	0 minutes spent on portfolios	Yes
January 17, 1996	25 minutes: portfolio presentations	Yes
Totals	Total minutes spent since portfolio due date: 25 minutes	Total minutes spent on portfolios this semester: 185 minutes

APPENDIX B

Permission Forms

Sample Teacher Permission Form**STATEMENT OF PERMISSION**

I, _____, grant Teri Willard permission to review student responses to selected classroom assignments (listed below) during the first semester of the 1995-1996 school year. I also agree to allow her to gather data and to use my personal written or verbal comments in reports of this project. I acknowledge that every effort will be made to insure the privacy of everyone involved. Neither the school, the teacher, the class, nor individual students will be identified in any use of this information.

Signature_____

Date_____

Items to be reviewed:

- Student Questionnaire (2);
- Student portfolios including selection justifications;
- Classroom observations as approved by teacher;
- Interviews as approved by teacher (both student and teacher);
- Lesson plans, course syllabus, grading schemes.

Sample Teacher Agreement Form

I, _____, agree to the following conditions negotiated with the researcher, Teri Willard. This agreement will be in effect from the date of signatures below until about the twentieth week of the school year, 1995-96.

- (1) to provide the researcher with a written plan for a teacher-directed portfolio, including the goals I hope students will achieve through the use of portfolios;
- (2) to allow students some freedom in selection of items for the portfolios, within guidelines set by me, and to require the students to write a justification of each selection;
- (3) to assist the researcher in collecting the student permission forms;
- (4) to be personally interviewed three times;
- (5) to allow focus students to be interviewed three or four times;
- (6) to administer a questionnaire twice during the study;
- (7) to allow the researcher to observe the classroom;
- (8) to discuss weekly on the telephone the classroom occurrences relating to portfolios;
- (9) to have the students compile special NCTM Goals Portfolios (a sheet of guidelines will be provided for each student by the researcher) twice during the semester; and
- (10) to allow the researcher to collect and review the NCTM Goals Portfolios (I & II) before I assess them.

_____(Signature of teacher)

_____(Signature of researcher)

_____Date

Sample Student Permission Form

LETTERHEAD

Date

Dear Student:

The first semester this year in your mathematics class, I plan to focus on methods for assessing and communicating progress in mathematics. Teri Willard from Montana State University in Bozeman will be helping me by visiting the class, interviewing some students, and reading your work. This means that you will have extra help in improving your communication skills and understanding mathematics. We may share your work and comments with prospective teachers and others interested in improving mathematics instruction. She may also ask to interview you during the semester. As we share this important information, every effort will be made to insure the privacy of everyone involved; neither the school, the teacher, the class, nor individual students will be identified in any use of the information gathered.

I am writing to inform you about what we hope to accomplish this semester and to ask for your support. If you agree to participate or, if for some reason, you would rather that your work not be directly involved, please sign on the appropriate line below.

If you have any questions or concerns, please feel free to talk to me. Thank you for your help.

Sincerely,

I, _____ (print name), agree to participate.

_____(signature)

I, _____ (print name) do NOT want to participate.

_____(signature)

Sample Parent Permission Form**LETTERHEAD**

Date _____

Dear Parents/Guardians:

This first semester of the school year in your child's mathematics class, I plan to focus on methods for assessing and communicating progress in mathematics. Teri Willard from Montana State University in Bozeman will be helping me work with my class. She will also help me by visiting the class, interviewing students, and reading students' work. We may share your child's work and comments with prospective teachers and others interested in improving mathematics instruction. She may also ask to interview your child during the semester. As we share this important information, every effort will be made to insure the privacy of everyone involved. Neither the school, the teacher, the class, nor individual students will be identified in any use of this information.

I am writing to inform you about what we hope to accomplish this semester and to ask for your support. Whether you support our efforts or, for some reason, you would rather your student's work not be directly involved, please sign on the appropriate line below. Your student has also been given a separate consent letter to sign. Both of you must consent if your student's work is to be anonymously shared.

If you have any questions or concerns, please contact me at school. Thank you for your help.

Sincerely,

I give my consent for _____ (print student's name) to participate. _____ (parent/guardian signature)

I do NOT want _____ (print student's name) to participate. _____ (parent/guardian signature)

APPENDIX C

Data Documents

NCTM Goals Questionnaire

(Note: On the questionnaire given to students, the questions were all listed with no space to answer beneath a question. Students were given additional sheets of paper to write their answers.)

FALL STUDENT QUESTIONNAIRE

Name _____

Date _____

Please answer the following five questions. Number your responses.

1. What does it mean to value mathematics? How can you show someone that you value mathematics?
2. What does it mean to be confident in your ability to do mathematics? How can you show someone that you are confident in your ability to do mathematics?
3. What does it mean to be a mathematical problem solver? How can you show someone that you are a mathematical problem solver?
4. What does it mean to communicate mathematically? How can you show someone that you can communicate mathematically?
5. What does it mean to reason mathematically? How can you show someone that you can reason mathematically?

Teacher's Grading Plan

Tentative Integrated Math Level V Grading Plan

You will be graded on a point system this quarter. There will be between 500–1000 points possible per quarter.

Tests and quizzes: 25 pts – 100 pts (approx 300 pts/quarter)

You will be given tests and quizzes regularly. On occasion there will be group tests or take home tests.

Participation: 100 pts

You will be given 100 pts at the beginning of the quarter. You will be expected to participate in all activities and work hard all period to keep these points.

Come to class with all supplies and be in your seat and quiet when the second bell rings.

Folders: 20 pts each (approx. 100 pts)

You will be expected to keep a notebook with all your work in it. At the end of each module you will be given a folder. You must put each activity, notes, and a summary of the module in this folder. In addition, you will be asked to select certain pieces of work to place in a portfolio with a written explanation of why you chose it.

Daily Work: 5 pts – 30 pts each (200 – 300 pts/quarter)

Completion grade – 5 pts (I check that you did it)

Random problem – 10 pts (I pick a problem randomly to score)

Scored activity – 10 – 30 pts (I grade the whole activity)

special projects – pts vary

You are expected to complete every assignment to the best of your ability.

Year long portfolio:

I will keep a portfolio in my file cabinet to keep various samples of your work that will be selected by you and by myself. At the end of the first quarter you will be required to begin work on an NCTM goals portfolio and will earn a completion grade. At the end of the semester you will complete the NCTM goals portfolio and I will review the portfolio with you and a grade will be assigned.

Journals:

Everyone will be required to keep a journal.

Teacher's Course Goals

(Note: This was not given to students, but was only shared with the researcher.)

Integrated Math V Course Goals

1. Give students opportunity to experience success so they will become more confident in their ability to do math.
2. Provide students with a variety of tools to solve challenging problems so they can overcome their weaknesses and excel in mathematics and become mathematical problem solvers. (Some of my students are still weak in algebraic manipulations and computation skills in fractions and decimals. I want them to be adept in using technology so that these weaknesses do not keep them from reaching higher levels of achievement in mathematics.)
3. Encourage students to be risk takers.
4. Provide a variety of real world contexts for the mathematics content so students will learn to value mathematics.
5. Give students many opportunities to explain, justify, prove, and verify the work they do so they will learn to communicate mathematically.
6. Provide students with many and varied situations where they need to think, apply various problem solving strategies, use various tools, and problem solve, so they will learn to reason mathematically.

Fall Portfolio Reflection Sheet

Portfolios '95 – '96

Questions for discussion:

Look over the portfolios, and what you wrote last year.

1) What would you like to do differently this year? Why?

2) What would you like to keep the same this year? Why?

3) Is there anything you would add to this portfolio to give someone reading it more information about you or your mathematical abilities?

4) Why do you think that people that see these portfolios are so impressed?

Teacher's Guideline for the NCTM Goals Portfolio

Guideline for NCTM Goals Semester Portfolio

Portfolios are ongoing pieces of work. At the end of the first nine weeks we will begin putting together an NCTM goals portfolio. When you prepare your NCTM Goals Portfolio, you need to include items that demonstrate your ability in each of the five areas (see the NCTM goals listed below). A single item may show one or more of the goals. If by the end of the first quarter, you can not find an item that is satisfactory, you will write and tell me what kind of item you would like to put in the portfolio and why. You will be given a completion grade at the end of the first quarter.

By the end of the semester you will have found seven, separate, and appropriate items or have done special work to complete the semester portfolio. You must show all five NCTM goals in this portfolio. You and I will review the portfolio and a grade will be assigned.

NCTM Goals:

1. Students will learn to value mathematics.
2. Students will become confident in their ability to do mathematics.
3. Students will become mathematical problem solvers.
4. Students will learn to communicate mathematically.
5. Students will learn to reason mathematically.

Requirements:

1. Table of Contents
2. Attach a written statement telling the goal or goals for each item, how each item exemplifies those goals, and why you picked the item.
3. Include seven separate items chosen from homework, projects, tests, quizzes, summaries of modules, math diagrams, or pictures you drew, computer print outs – like spreadsheets or graphs used to solve a problem, report on math topic or math person, or any item you think shows your ability.
4. You must show all five NCTM goals in this portfolio. (you may do special work for this portfolio)

Additional Guideline for the NCTM Goals Portfolio

(Given by the teacher one week before the NCTM Goals Portfolio II was due)

Semester Portfolio Reminders

1. This portfolio is worth 100 points and will be presented to the class during semester exams. This will be your semester exam grade!! The presentation and portfolio will be graded.
2. The portfolio must have the requirements as listed on the portfolio handout [Guideline for NCTM Goals Semester Portfolio].
3. Don't forget to organize the portfolio and make a table of contents on the computer.
4. Write a one page description of yourself, your hobbies or interests, your future goals, your mathematical strengths, your mathematical weaknesses and what you think people who read this portfolio will conclude about you as a person and as a math student. (Use the computer)
5. Decorate the cover of the portfolio so it will help the reader learn more about you as an individual.

Portfolio Reflection Sheet

(given one week before the NCTM Goals Portfolio II was due)

Journal

Your semester NCTM goals portfolio will count as a test grade (100%) this quarter.

Your first draft was turned in at the end of the quarter and counted 50 points.

Unfortunately, some students in the class put little or no effort into their portfolio. The ones that were completed at the end of the school year last year were outstanding.

What is your theory on this?

Do you feel you were one that put effort into the portfolio? Why or why not? Explain fully.

Everything can be improved. What do you think you can do to improve your portfolio?

Guideline for Portfolio Presentations

Portfolio Presentations

This will be very informal.

1. Pick one item that you placed in your semester portfolio that is your favorite and tell us why.
2. Tell us what you gained from doing this portfolio.
3. Do you think a portfolio is a good way to assess the five NCTM goals (valuing, confidence, reasoning, problem-solving, and communication)? Explain.
4. Would you recommend using portfolios at [this school] as a way to assess our curriculum. Why or why not?

Three Additional Problems Given by the Teacher

The Drug Problem

When a drug is taken into the bloodstream, the body works to remove it. Suppose the body removes 20% of a certain drug every 4 hours. The body needs at least 100 mg of this drug to be effective, but more than 1000 mg of the drug is dangerous. A doctor wants to prescribe an amount of the drug to be taken at regular intervals. How much of the drug should be taken? How often should it be taken?

The Grasshopper Problem

An entomologist (insect scientist) wants to estimate the number of grasshoppers in Prairie Park, a region of 25,000 m². She stakes out 5 squares, each 10 m x 10 m, randomly arranged around the Park, and carefully counts the grasshoppers in each square. Here are the results:

square	1	2	3	4	5
number of grasshoppers	18	3	12	15	20

- a.) The entomologist would like to be able to say, "On this day, there were at least _____ grasshoppers in the Park." What number would you suggest in this blank? Tell how you determined this.
- b.) Is this a good method for counting grasshoppers in a large area? How could it be improved?

The Salary Problem

The boss for your summer job has offered you two plans for your pay.

Plan A: She will pay you \$100 the first day, \$200 the second day, \$300 the third day, and so on.

Plan B: She will pay you \$.01 the first day, \$.02 the second day, \$.04 the third day, \$.08 the fourth day, \$.16 the fifth day, and so on.

If the job lasts for 30 days, which plan would you choose and why?

Student Justification for the Best Piece Portfolio
(Teacher-directed portfolio)

[NAME OF MODULE] Module Portfolio Selection

Pick one item from the [NAME OF THE MODULE] module that you consider your best work in this module. It can be one problem from one lesson, a whole activity, one problem from a test, a complete test, etc... It can not be one of the review worksheets.

1. Explain why this piece is the BEST!!!! Use complete sentences!!!!

2. What was the criteria you used to pick the best piece of work? Use complete sentences!!!!

Sample Observation From Jan. 3, 1996

(Notes were typed as written by the researcher, but words were added in brackets if the meaning was unclear.)

RESEARCHER
COMMENTSRESEARCHER OBSERVATIONS

1:35 p. m.

So today they start
out with oral
presentations.

Teacher is giving them their folders and she also wants to see their module selections. M. came in talking about not being done with the problem. J. is back. Teacher turns on overhead and asks for their thoughts. M gets up to present. M. writes on overhead.

$$y = A \circ b^x$$

$$y = 8 \circ b^x$$

Then he says they didn't know what to do so they tried 500 mg every 4 hours and found they stayed over 100 mg.
Shows his work.

500

.20

100

500

600

.20

120

500

620

.20

140.

500

640

.20

128

He is using the
amount lost as the
amount left in the
body.

Then M. says that is only for one day.

(Observation notes were continued using this format with researcher's comments in the right hand column. On the next page are notes from later in the same class period to demonstrate the type of notes taken.)

SAME CLASS PERIOD BUT LATER TIME

1:52

She's [teacher] going to get them started on folders but now she's going to give them a homework problem to go in their folders. She says, "You're not redoing the work you did before, you're just improving. It's like your 1st draft and now you're editing it." Tells them about presenting and doing a sheet for the researcher on Jan. 18 or 19. "We're doing this [the portfolios] to get it out of the way." She reads them the NCTM goals. Tells them about evaluating her math curriculum. "One way might be a portfolio." She reads them the directions. "If what you wrote is OK, leave it – edit and put on new sheet. Keeps saying not to redo but they should edit.

She seems nervous.

She shows them good example from last year. C. asks if they can leave it if they like it. Teacher says "Yes," but you may want to add a little. Tells them whose paper she is showing and she wants them to look at it. She wants to show them what's expected.

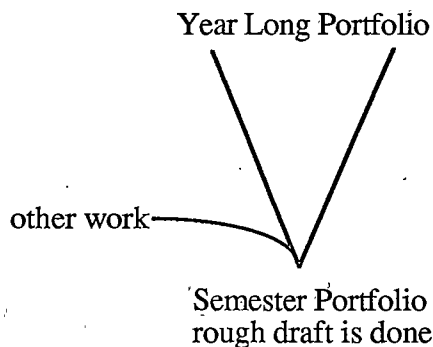
2:00

Now they are all reading it [the example]. Teacher says it doesn't have to be that long. She says, "technology is one of the school goals we picked for our school." Teacher reads the explanation and says the student clearly pointed out why she picked it.

She says she'll give them folders and some suggestions. She's going to give it as 10% of semester grade and she wants some good effort. "The first time I went through [the portfolios] real quick but now I went through them more carefully." "All I want you to worry about today is these statements (the NCTM goals)." "Later we'll write a little statement about yourself." Gives back their best picks and says they don't have to use them [in the goals portfolio].

Teacher asks J. where her folder is. She says at home. M. asks where to put his best pick. Teacher says in his folder. "Your folder is what I consider your year-long portfolio," she says and draws this on the board.

I am confused.



Log Jam is the module I'm short.

Teacher seems to be taking some ownership of the portfolios, now.

2:15 - class is over

Teacher shows them some colored binders. "You'll have 5 of the goals - then you have 7 items altogether. How you want to deal with the extra is up to you." M. asks, "Can you have just one problem." Teacher gives a long explanation of how it can be one problem not a whole test or homework assignment. Calls it "your working folder." She'll let them work now - tomorrow talk about table of contents and organization. M. asks how many modules he'll have as she passes back the module folders.

M. asks K. a quiet question - I can't tell what she wants.

C. asks if the portfolio is the homework.

Teacher says, no, it's the problem she just gave them [the doubling one]. K. asks if she can do it on her calculator. Teacher tells her to think about the last module and she'll probably find a formula. Teacher says, "We'll work on it tomorrow in class." Teacher says portfolios are due on Monday at the beginning of class. "Then you won't see them again til semester test when you'll just show it."

Fieldnotes from Jan. 4, 1996

It is getting to be a routine – I get up in the morning, turn on the weather channel and then call the highway road report. This is the third day that they have predicted very bad weather. Today there was a snow and blowing snow advisory but the road report was good. The temperature today is much colder than yesterday. Just to be safe, I repack my suitcase like I have done for the two previous days and throw it in the car with several extra blankets. At least if I get snowed in, I will have clean clothes. If I end up in the ditch, I will be warm.

The drive over was better than I expected. I arrive at the school at 12:20 for a 1:46 class. The schedule has been mixed up all week. Tuesday is their regular day of shortened classes because of an after school tutorial program. Wednesday was a teacher in-service day and today is a pep rally. Supposedly Friday will be normal except for a freshmen ski day which does not affect the SIMMS kids.

I find the teacher in the teacher's lounge and we visit for a few minutes. I also visit with another teacher that I know at the school. I stay in the teacher's lounge until the SIMMS class begins. The teachers are discussing problem students.

During and after the SIMMS class, the teacher and I discuss the pick-up plan for the portfolios. I think I will pick them up on Jan. 11 and interview on Jan. 12. That way I'll be sure that the student who was absent will have his done. The teacher also gives me copies of a writing assignment the student's did called "What is SIMMS anyway?"

Students were anxious for the Pep Rally and stopped working about 5 minutes early.

I will probably confirm the interview schedule tomorrow and then call the teacher on the 10th or 11th.

The snow and blowing snow never materialized. The drive home is basically good.

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