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
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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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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.

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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.

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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.

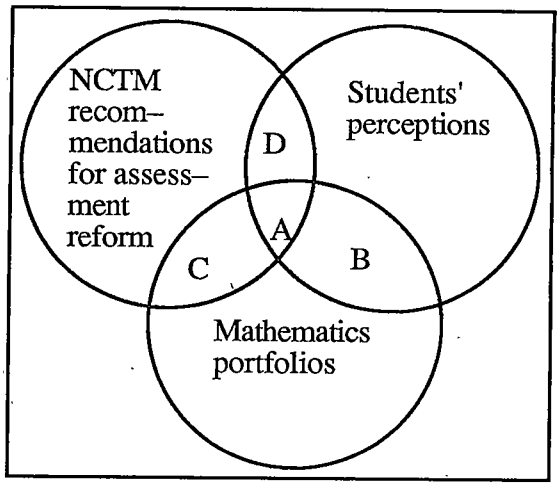
Portfolios, and other alternative assessments, have the potential to effect changes in education. However, Herman and Winters made a crucial point: "The quality of change and the efficacy of the new practices must be subjected to inquiry" (1994, p. 55). By conducting this study, the researcher hoped 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 students 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