The level of teacher involvement in the Vermont mathematics portfolio assessment process and instructional practices in grade 4 classrooms

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THE LEVEL OF TEACHER INVOLVEMENT IN THE VERMONT MATHEMATICS PORTFOLIO ASSESSMENT PROCESS AND INSTRUCTIONAL PRACTICES IN GRADE 4 CLASSROOMS

BY

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DISSERTATION
submitted to the University of New Hampshire in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Education
May 2001
This dissertation has been examined and approved.

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DEDICATION

To my husband Jim,

who insisted.
ACKNOWLEDGEMENTS

The completed work in this document reached the publishers because of the unwavering support of my family and friends. I am thankful to all those individuals who offered a kind word or a supportive thought that helped me continue on the path. I mention those individuals by name that continued to encourage me through the difficult times and the junctures that seemed impossible. In the doctoral seminar Charlie Ashley convinced us that we could all complete the doctoral program. When I moved to Vermont, the distance proved to be a huge barrier, but I continued my work with encouragement through E-mail and holiday lunches with Mimi Struck, Bette Chamberlain, and Mary Jane Moran. Thanks ladies.

I sincerely appreciate the many educators in Rutland County for their suggestions and helpful feedback as I developed the proposal. I am particularly grateful to the teachers who took the time to complete the survey. My special thanks to Linda Johnson, Carolyn Magwire, Linda Barker and all the teachers at West Rutland School who knew I could succeed and kept me moving forward. Thanks for piloting the survey and listening to me as I wrestled with the proposal. I thank Richard Rivers a student from West Rutland School who was always willing to help.

I am truly grateful to Dr. Judy Robb whose enthusiasm for my idea bolstered my confidence so I could continue with the work. I appreciate the committee members, Dr. E. Janet Jamieson, Dr. Georgia Kerns, Dr. Karen Graham, and Dr. Casey Cobb for their wide range of expertise and their guidance. Thanks for giving me your time and sharing your ideas.

v

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And finally, I am most thankful for my family. I could not have reached the end without their patience and support. Your encouragement carried me to completion even though the challenges appeared overwhelming. Thanks Susan for siding with Jim, I was ready to quit. Thank you David for being yourself. Mom, keep on praying, it really works and kids, stay in college. Education is the key that will open all the doors to your dreams.
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ABSTRACT

THE LEVEL OF TEACHER INVOLVEMENT IN THE VERMONT MATHEMATICS PORTFOLIO ASSESSMENT PROCESS AND INSTRUCTIONAL PRACTICES IN GRADE 4 CLASSROOMS

by

CAROL FRITZ

University of New Hampshire, May 2001

The comprehensive assessment system in Vermont includes student mathematics portfolios that are submitted to the state Department of Education for scoring. A student portfolio should include 5-7 pieces of best work selected by the student that can be scored. This alternative assessment process has been in place for ten years, but limited information has been available from classroom teachers about the instructional practices they use when teaching mathematics, or whether or not those practices have been influenced by the portfolio process.

The study was developed to answer questions about the instructional practices used by teachers. Teachers’ responses were compared to their level of involvement with the mathematics portfolio assessment process. A twenty-question survey regarding instructional practices was distributed to all grade 4 teachers in Rutland County, Vermont. Demographic information was collected about the number of years teaching, including the teaching of mathematics. Teachers were asked about the frequency of their participation in the portfolio training and calibration sessions.
37 teachers from 19 schools responded. Study data indicate the following: there were seven different curricula in use, each school using a school wide adopted program. There was a high level of participation in the portfolio training sessions, and 50% of the teachers chose to participate in the formal portfolio scoring process. The teachers were asked to respond to seven Likert scale items about the degree of frequency with which they included specific instructional practices in their classrooms.

Over the three years teachers in the study did show an increase in the types of instructional practices that supported the portfolio process. Each such teaching strategy was used more for each year surveyed and portfolio problems were incorporated more frequently. Teachers also reported supplementing the mathematics curriculums with computational practice.

During the same period of time Vermont added a high-stakes performance assessment for Grade 4 students. Student performance on the state assessment in mathematics improved each year included in the study. Portfolio scores also improved. Teachers indicated growing support for using the portfolio process. They felt that the process potentially provided more opportunities to construct mathematical understanding and communicate solutions. Despite growing support for the portfolio process and curriculum changes to support it, teachers who were interviewed reported that they did not specifically review state scored portfolios of their own students, although such review and potential instructional revision was part of the original state mandate.
CHAPTER I

INTRODUCTION

Public schools have received national criticism for poor student performance in mathematics for the past fifteen years. The national attention given to the *Nation-at-Risk* report (National Commission on Excellence in Education, 1983) startled educators and opened the door to self-reflection about instructional practice, student performance and reporting assessment scores to the public. The National Council of Teachers of Mathematics convened a group of educators from public schools and colleges, and professional mathematicians to explore strategies and techniques that would increase student performance on national assessments (Commission on Standards for School Mathematics, 1989; Reese, Miller, Mazzeo, & Dossey, 1997). The public wanted academic improvement from students and a higher standard of performance from teachers (Commission on Standards for School Mathematics, 1989; Department of Labor, 1991; National Commission on Excellence in Education, 1983; National Education Goals Report, 1997). A similar demand for accountability by parents and taxpayers in Vermont led to the formation of a committee of teachers and consultants who were given the assignment to develop a comprehensive assessment process that would reflect student mathematical knowledge.

The Vermont Department of Education convened a team that began the work in the spring of 1989 (Vermont Mathematics Portfolio Resource Book, 1991; Vermont State Board of Education, 1993). The members of the team included teachers, a state
mathematics consultant, a consultant from TBA Consulting Group, and a statistician from
Advanced Systems in Measurement and Evaluation, Inc. (Department of Education,
1991). Resources including experts in the field of mathematics were made available to
facilitate the process. Vermont teachers were important members of the team since the
work that needed to be done was in classrooms and became the focus of the assessment
process. The standards developed by the National Council of Teachers of Mathematics
(Commission on Standards for School Mathematics, 1989) were the framework for
developing the assessment process.

The work completed by the Vermont team led to the creation of an assessment
procedure, the mathematics portfolio assessment process. This assessment process was
designed to measure students' mathematical knowledge of complex problem solving and
their ability to communicate this mathematical understanding (Vermont Department of
Education, 1991). The mathematics portfolio assessment process was piloted by grades
four and eight teachers during the 1990-1991 academic year in 137 schools across the
state (Abruscato, 1993). The pilot schools were volunteers. Participation in the portfolio
assessment process became a requirement for all schools in spring 1997 following the
Board of Education approval of a state comprehensive assessment system (Vermont
Department of Education, 1997). Since that time all schools are required to submit
randomly selected mathematics portfolios of student work for scoring on alternate years
for grades 4, 8 & 10.

The developers of the portfolio assessment process believed that frequent
opportunities to participate in the portfolio assessment process could assist students to
become effective problem solvers and good communicators of their understanding of
mathematics. Using the information from the NCTM curriculum standards (Commission on Standards for School Mathematics, 1989), the Vermont team created an assessment process that could give teachers the tools to assist students in their efforts to become mathematically powerful. The team intentionally developed a system that would provide students with many opportunities to consider multiple approaches to problems, to take risks, and to effectively communicate solutions. The team believed that the integration of problem solving into all aspects of instruction would engage students in complex thinking.

Theoretically, the proposed portfolio process would influence teachers to structure classroom models that encouraged students to ask questions, hypothesize, explore, and lead to discovery of solutions and mistakes. The students would need computers, calculators, manipulatives, models, charts, diagrams, tables, graphs, and pictures to solve problems. The students would need to work collaboratively in small groups. Frequent small-group work would offer students opportunities to work cooperatively together and learn from one another. The work of classroom teachers would change from direct instruction, to facilitated learning opportunities for students (Lappan & Briars, 1995; May & Haugen, 1995).

The team that developed the portfolio assessment process believed that teachers could gain important information about their students' understanding of mathematical concepts from reviewing the portfolios. The mathematics portfolio problems required students to develop solutions in four areas of mathematics: number sense and numeration tasks; geometry and measurement; probability and statistics; and functions and algebra. Sample problems were created by teams of teachers and were distributed to all schools. The “Garden Problem” that follows can be assigned to grade 4 students. It required
students to use geometry and measurement concepts. Student solutions to the problem could be included in student portfolios for grade 4. The problem was developed by teachers and included in the resource book that was distributed by the Department of Education (1991). It is one of many problems that can be assigned that required student knowledge of geometry and measurement.

Sample: Geometry and Measurement Task

Garden Problem

You are going to start your own garden, and you really want to grow as much as you can. Your mom gives you 50 feet of fencing so the deer won’t eat your garden. Design a garden that will give you as much space as possible. Tell how you solved the problem and why you decided to do it that way. Marie is selling seeds for $1.00 a package. She says that each package will cover about 10 square feet. (This includes the spacing needed between the plants and the rows.) Decide what you are going to grow, and how much you will spend on seeds. Explain all of your decisions. Be sure to address all parts of this problem (Vermont Department of Education, September 1996).

It was the expectation of the design team that the written explanations of the solutions would provide teachers with important information about their students’ mathematical thinking. The analysis of students’ portfolios could give teachers information about student progress and the effectiveness of the mathematics program used for instruction. Frequent use of the portfolio process could give teachers an opportunity
to reflect on instructional programs and pedagogical approaches. This was the assumption of the team that developed the mathematics portfolio assessment system (Department of Education, 1991).

The students' solutions were assessed using a rubric that was designed by a group of Vermont teachers. The rubric has two sections and each section included three categories. The sections are mathematical problem solving and communication. The specific categories which students received feedback for their solutions are approach and reasoning, connections, solution, mathematical language, mathematical representation, and documentation. The rubric is included in Appendix A of this document. The example given below of student work reached a Level 2 solution; that is, the approach led to solving only part of the problem or reached a partial solution.

Sample Solution: Approach and Reasoning for Garden Problem

The problem I had to solve today was making a garden. I had fifty ft. of fencing to make my garden with. With 50 feet of fencing I had to make the largest area I could. We had seeds too, although we had to buy them. Each packet cost $1.00. Each packet of seeds would cover ten ft. of land. I had to find out the cheapest way to build my garden and find out how much the seeds would cost. I started solving this problem by making a rectangular garden that was 10 x 15 ft. I made 13 plots that each had ten square ft. in each. Since there was still twenty feet left, I made those areas, walkways. Next I counted each plot, except for the walkways as one dollar. To finally get the perimeter and area, I multiplied 15 x 10 to get the area, 150 square feet and I added ten and ten to get twenty and fifteen + 15 to
get thirty. I added those two together to get 50 ft.

So what?

While I was working on this problem I noticed that I made my ten square ft. patches into all different shapes. I could have made almost the same looking groupings in my second one but it would have come out costing the same amount.

Two drawings were included with the explanation (Vermont Department of Education, 1997).

The cited example of student work and many other samples were made available to all teachers by the Department of Education. Sample problems and benchmarked solutions were distributed to schools in 1997 so teachers could use the information in their classrooms. Additional problems and benchmarked solutions were distributed annually at teacher training sessions so the resource materials continued to expand.

The Department of Education prepared a resource manual that included detailed information about the process for all classroom teachers to use. The manual was distributed to all schools in the fall of 1991 (Vermont Department of Education).

The portfolio assessment process has two distinct components:

- Student achievement in problem solving and mathematical communication as measured through best pieces in a student portfolio.

- Teacher evaluation of instruction, content area, and program as measured through a review of entire portfolios (1991).

These two components provided different lenses to view mathematics instruction and student learning (Department of Education, 1991) and defined for teachers the work
necessary for student success. The educators who worked for the Vermont Department of Education were concerned that students needed the tools to become complex problem solvers who could explain their thinking both orally and in writing. The educators observed rapid changes in our society and listened to the demands of the business community (National Commission on Excellence in Education, 1983) for students to join the work force ready to be complex problem solvers using a collaborative process. The combined information convinced Vermont educators that their efforts to reform mathematics instruction could prepare students to enter this world.

The mathematical knowledge could prepare students for an environment where few situations will have “right” answers and conventional solutions for many problems will no longer work. The Vermont educators were convinced that students would need additional tools to approach the challenges they would face. The mathematics instruction provided to students must prepare them to apply mathematical concepts to meaningful life situations and make the connections to other disciplines (Peak, 1997). The mathematics portfolio program was designed so students would have the skills to succeed; they would be able to solve complex problems and communicate the solutions.

The Department of Education provided classroom teachers with training to score sample portfolio problems for each of the four areas of mathematics assessed by the portfolio process. The training sessions called “Network Meetings” were available for teachers who scored student work. Training sessions were available for teachers who scored grade 4 and grade 8 using one rubric and separate sessions were conducted for teachers who scored student work from grade 10. There was a different rubric designed for grade 10 student work. Classroom teachers who were trained by the Department of
Education conducted the Network meetings for area teachers. The portfolio scores generated during the first two years were scrutinized for reliability (Koretz, Stecher, Klein, McCaffrey, & Deilbert, 1993). The findings suggested that teachers needed additional training opportunities for scoring pieces. Interviews conducted by the researchers suggested that the teachers needed to expand their understanding of mathematics in order to use the process more effectively. Using that recommendation, training opportunities were offered in mathematics for classroom teachers by teacher associates from the Vermont Institute of Science, Mathematics, and Technology. Additional training sessions were conducted each year so teachers who scored portfolio pieces were accurate. The “Calibration Sessions” were offered annually throughout the state to assure that the scoring was reliable (Vermont Department of Education, 1997).

However, there remained a need to inquire about instructional practices currently used by classroom teachers and learning opportunities that were available for students who must complete the portfolio work. Through the use of a survey, grade 4 teachers in the current study were asked how and when they included problem solving and mathematical communication in their instructional practice. If students are to become complex problem solvers and good communicators in mathematics, are teachers using the portfolio assessment process to facilitate student learning? Are students given frequent opportunities to work in small groups, communicate their solutions and given feedback from their teachers? Data derived from the study were analyzed to determine a possible relationship between the level of scoring and specific instructional practices that support complex problem solving and mathematical communication. Is there a relationship between the instructional practices used by the teachers and the level of scoring of student
work (100% local scoring, 20% state scoring or no scoring)? What instructional practices were used by teachers when they assigned portfolio pieces if they scored 100% of the work?

The National Council of Teachers of Mathematics (1989) committed to improving the quality of mathematics instruction by setting specific standards. The NCTM standards for problem solving and communicating mathematically that were published in the 1989 document were the two standards that underpin the mathematics portfolio assessment process designed by Vermont educators. The student portfolio assessment process is aligned with the design change in instruction envisioned by National Council of Teachers of Mathematics (Commission on Standards for School Mathematics, 1989). The mathematics portfolio process was developed to help teachers align curriculum and instructional practice that would support students as they work to meet the standards (Romberg, 1992). A standards-based curriculum (based on reform oriented NCTM standards) was recommended as an essential component combined with instructional practices that would make students mathematically powerful (Commission on Standards for School Mathematics, 1989).

The portfolio process has been in place for nine years. Students are assessed through this process and schools receive data that can be reviewed by teachers. The first component identified in the process has been met; students are participating in the portfolio process. The question remains: are teachers using the data from the portfolio process? Is the mathematics portfolio assessment process impacting decisions about instructional practice?
Central Research Question

The purpose of this study is to examine the instructional practices of grade four teachers in the area of mathematical communication and problem solving, the two NCTM standards that are the basis of the Vermont mathematical portfolio assessment process. Specifically, conducting the study is an effort to answer the following question: "Is the way in which grade 4 mathematics is taught among Vermont teachers related to their level of involvement in the portfolio assessment process?"

Mathematics portfolios are one component of the Vermont comprehensive assessment system. Teachers are required to submit portfolios from students in grades four, eight and ten. The students are expected to complete mathematics portfolio problems every year with pieces submitted on alternate years. Limited information is available from grade four teachers about the instructional strategies used to prepare students for solving the portfolio problems since participation in the portfolio process became a requirement. Teachers are required to submit student work, but do they use specific instructional strategies if they are participating in portfolio training sessions and scoring all student work? The system has been in place for nine years, and researchers asked teachers about their work during the first and second year of implementation (Stecher & Hamilton, April 1994; Stecher & Mitchell, 1995; Stecher & Mitchell, April 1995; Koretz, August 1994; Koretz, Stecher, Klein, McCaffrey, & Deilbert, December 1993). The study by Stecher & Mitchell (1995) asked teachers in the second year of implementation to explain their understanding of problem solving as an instruction tool. The study suggested that teachers did not have a clear understanding of problem solving, and professional development would be needed to broaden teacher knowledge.
Technical Report 371 (Koretz, et. al., 1993) offered some information about instructional practice in the first year of implementation. Many educators reported a powerful and positive influence on instruction. Mathematics teachers reported devoting more time to problem solving and communication. More time was given to exploration of mathematical patterns, applying mathematical knowledge to new situations, 70% reported devoting more time to making charts, graphs, and diagrams. Grade 4 teachers reported allocating more class time to writing about mathematics. Teachers reported that students were given more opportunities to work in small groups or in pairs and that their attitude toward mathematics instruction was more positive. Educators reported that the program had caused even recalcitrant teachers to change their instruction. The researchers found a wide range of implementation of the portfolio program that reflected the degree of autonomy afforded by the program when it first began (Koretz, et. al., 1993).

The data from the portfolio assessment can give information about students’ understanding of complex problem solving and the application of mathematical concepts, but limited research data are available about instructional practice since the portfolio assessment process became a requirement for grade four classrooms. Teachers in grade four have not been asked if they provide students with opportunities to work in small groups, explain their solutions to complex problems in writing or orally, or focus their instruction on problem solving. In addition, it would be helpful to know the focus of their instructional practice different since the portfolio assessment process became a requirement.
Statement of Significance or Importance

This study is an effort to discover if a relationship exists between mathematics instruction and the level of involvement of teachers in scoring portfolio pieces. Is there an instructional difference between teachers who are very involved in the assessment process and teachers with limited or no involvement in the assessment process? The study would give classroom teachers an opportunity to contribute first hand information about the impact of the mathematics portfolio assessment process on their mathematics instruction. The information gathered from the study would be available to other classroom teachers who have questions about the use of portfolio assessment in grade four classrooms (Stecher & Hamilton, 1994). The results of the study could expand the information about the impact of the process to teachers who are required to use this assessment tool, and it would broaden the information available about the instructional practices in mathematics currently used in grade 4 classrooms.

The most recent information about the use of the mathematics portfolio process was collected from a teacher survey about learning opportunities for students. The Department of Education (1998) conducted the survey. The data analysis compared student performance on the mathematics portfolios to student performance on the New Standards Reference Exam in Mathematics (Department of Education, 1998). All grade 4 students take the New Standards Reference Exam in the spring; it is a required component of the Vermont Department of Education Comprehensive Assessment System (1997). Student performance on the New Standard Reference Exam was compared to student performance on the mathematics portfolios. The comparative data supported continued use of portfolio assessment, but the instructional practices used by teachers of these
Review of Previous Research on Vermont Portfolio Assessment

Implementation of the Vermont mathematics portfolio assessment process during the 1991-1992 school year attracted national attention. Vermont teachers appeared committed to a statewide assessment process that required elementary students to solve complex problems and communicate their solutions in writing. The portfolio process began with a pilot group that included students in grade 4 & 8 with grade 10 students joining the portfolio process in 1995. Currently all mathematics teachers who have students in grades 4, 8 & 10 must include portfolio problems in their classroom instruction. Students are required to review their collections of open-ended responses to mathematical problems and to select five to seven of their best pieces to be submitted for scoring. The process was designed with the expectation that students would solve multiple portfolio problems each school year. The classroom teacher could assign problems each week, at the end of a unit of instruction, or the students could work together in-groups to solve problems. The expectation was for students to have frequent opportunities to solve complex problems and communicate the solutions. The program design was structured so students would have ten to twenty pieces completed during the school year. The students could select their best pieces for submission from the many choices available.

Teachers who volunteered for summer scoring sessions scored the mathematics portfolios that were submitted from schools all over the state (Vermont Institute of Mathematics, Science & Technology, 1996 & 1998). The portfolios submitted for summer scoring were scored by some teachers prior to submission. Teachers were not...
required to score the pieces prior to submission.

Early results reviewed by Abruscato (1993) suggested that teacher support would be necessary to continue the use of portfolio assessment and school districts would need to allocate resources for the process. Teachers would need to participate in training sessions to help integrate the portfolio assessment process into mathematics instruction, so that it is not treated as an addition.

The first year of implementation of the Vermont mathematics portfolio assessment process (1991-1992) received considerable attention from the Center for Research on Evaluation, Standards, and Student Testing (CRESST) located in Los Angeles. A team from the center gathered information from teachers and principals in an effort to understand the impact of this innovative assessment tool (Koretz, Stecher, Klein, McCaffrey, & Deilbert, 1993). The technical report (371) included information about the implementation of the program, the effects of the reform on educational practice, the analytical challenges presented by the portfolio scoring process, the reliability and validity of portfolio scores, and the tensions between assessment and instructional reform. The research group used a random stratified sample of classroom teachers and requested that the teachers complete a questionnaire. A summary of the responses to the questionnaire indicated that participation in the portfolio process was extensive and that the program appeared to have a positive impact on instruction. The following is a summary of the findings. (Note: The author in e-mail indicated that the questionnaire is not available.)

Virtually all-fourth and eighth grade mathematics teachers received state sponsored training in the use of portfolios. They generally rated this training
as effective. Nearly all fourth and eighth grade students compiled portfolios of their mathematics work. Teachers report devoting substantially more attention to problem solving and communication in teaching mathematics as a result of the program. Teachers reported some changes in mathematics instructional practice; for example, students spent more time working in small groups and in pairs (Koretz, et al., 1993, p. 12).

After the first year, teachers reported mixed results. They had new perspectives on students’ abilities, but there were concerns raised by teachers about the purpose of portfolios and the proper instructional practices they needed to use to implement the assessment system. Teachers did place more emphasis on problem solving, but they expressed concerns that it was at the expense of other areas of the curriculum, especially basic skills and computation (Stecher & Hamilton, 1994). Scoring the portfolios required time and placed burdens on teachers and schools. (Vermont Department of Education, 1997). The system has been in place for nine years and questions about the influence on instructional practice remain unanswered, although strong support for the program continues from teachers and the former Deputy Commissioner of Education, Marge Petit. The Department of Education added its support for continued use of the portfolio assessment process in the School Quality Standards (1999) used for school approval.

An evaluation report of the Vermont Portfolio Program by Koretz (1994) included interviews with principals from a random stratified sample of nearly 80 Vermont schools and questionnaires were completed by mathematics teachers statewide. Teachers who completed the questionnaire perceived that the program caused substantial change in instruction, but the program imposed substantial burdens on them. Scoring student
portfolios required additional time. Teachers reported that they added more group work for students. They provided more opportunities for students to write about mathematics solutions and directed students to make more graphs and charts. Six years have past since this survey was conducted. Additional information from teachers about their instructional practice in connection with the mathematics portfolios would broaden our understanding of the implications of continued use of this assessment process.

The demands for students to compete in a global economy and to have the skills to enter the workforce are reasons to support the continued use of the mathematics portfolio assessment process. The process requires students to engage in complex thinking and analysis. Vermont maintains its commitment of resources to the portfolio process, even though there is criticism about the burden that it poses on individual schools. Giving students the opportunity to become powerful mathematical thinkers can be accomplished by the consistent use of an assessment process that demands complex thinking and problem solving. Students must become mathematically literate if they are to be successful (National Council of Teachers of Mathematics, 1989).
CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Public school efforts to demonstrate improved student learning led the educational community to investigate alternative assessment methods for reporting what students know. These new assessment tools used standards defined by state and national organizations as the basis for reporting. Concern for poor performance by students in the United States resulted in the development of the National Assessment of Educational Progress, NAEP, a division of the United States Department of Education Office of Educational Research and Improvement. The first assessment was conducted in 1971 and included a mathematics component. The NAEP assessment program is conducted every other year and results are reported nationally (Vanneman, January 1998).

The documentation of poor student performance on the NAEP assessment gained attention that led to a national convention of governors. President Bush assembled the nations’ governors to discuss the situation in 1990. The governors who attended the summit agreed to set national goals for education. Three of the Goals (3, 4, & 5) established the context for the current study.

Goal 3: By the year 2000 all students will leave grades 4, 8, and 12 having
demonstrated competency over challenging subject matter including English, mathematics, science, foreign languages…

Goal 4: By the year 2000, the nation’s teaching force will have access to programs for the continued improvement of their professional skills…

Goal 5: By the year 2000, United States students will be first in the world in mathematics and science achievement (National Education Goals Report, 1996, p. 4).

The goals commonly referred to as Goals 2000, received financial support for teacher training and curriculum work. The United States Department of Education budgeted significant funding annually to support professional development programs for teachers. Funding awards were made to schools that developed plans to reach the identified goals. Vermont eventually obtained Goals 2000 grant money for assessment and professional development.

The National Council of Teachers of Mathematics added their voice to the concern about poor student performance in mathematics. The Council organized a team of educators that included classroom teachers, educational researchers, supervisors, teacher educators and university mathematicians and directed them to analyze mathematics instruction and assessment. The group was directed to develop a process for improved student performance in mathematics (Commission on Standards for School Mathematics, 1989). The group reviewed all available research about mathematics instruction and student performance on mathematics assessments as they began their work. The review included “A Nation at Risk” (National Commission on Excellence in Education, 1983) and
“Educating Americans for the 21st Century” (National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, 1983). Following extensive work by the mathematics experts brought together by the National Council of Teachers of Mathematics, a draft of standards for mathematics instruction and evaluation was published. The document titled *Curriculum and Evaluation: Standards for School Mathematics* (1989) is divided into four sections: Grades K-4, Grades 5-8, Grades 9-12, and evaluation. The National Council of Teachers of Mathematics completed important work that served as a framework for reform in mathematics instruction. The assessment section of the original document was clarified (1991) and a new standards document was released in April 2000. It continues to be a work in progress.

The NCTM standards that were published in 1989 undergirded the Vermont work to connect the standards to instructional practice. Many of the suggested teaching practices came from mathematics leaders involved with reform-based teaching that was based largely on constructivist theory. The new standards and recommendations for teaching mathematics from a constructivist approach received criticism from many practitioners (Cobb, Wood, & Yackel, 1990). Many were concerned that this instructional approach using the standards was not applicable to low-income students in urban settings. The research study of Ginsburg-Block and Fantuzzo is important to the current study because it was conducted with a group that is similar socioeconomically to many communities in Rutland County.

The research study conducted by Ginsburg-Block and Fantuzzo (1998) raised questions about the effectiveness of standards-based instruction with low-achieving elementary students. The researchers set out to assess the effectiveness of using

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standards as the basis for instruction with a specific population that met the criteria, low income and low achieving. Previous research on mathematics programs that incorporated a constructivist approach had shown promise for students so the study parameters were created to include instruction in problem solving with manipulatives (Prevost, 1996).

The Ginsburg-Block and Fantuzzo (1998) study examined two instructional methods, problem solving and peer collaboration and their effect on mathematics achievement, academic motivation, and self-concept of low-achieving 3rd and 4th graders. Students were randomly assigned to one of four conditions: control, problem solving, peer collaboration, and problem solving and peer collaboration combined. The students were given a curriculum-based computation test prior to the treatment. The test items were selected from The Mathematics Experience (1989), the series used in the school district. The series was described by its authors as being based on the NCTM standards (1989).

The students met in the treatment groups twice a week for 30 minutes each time for a period of seven weeks. Students who participated in the problem solving treatment group correctly computed a higher rate of computations per minute than did students in the non-problem solving treatment groups. Overall, students who participated in the problem solving group had higher rates of accurate word problem solutions than students did in other groups. Intervention outcome findings indicated that there was a significant positive main effect for the problem solving treatment on mathematics, academic motivation, academic self-concept, and social self-concept outcomes. This finding supported previous research that found approaches to elementary mathematics instruction that included problem solving to result in positive academic outcomes for students (Campbell, 1996). The current study will examine teaching strategies in Rutland County
that support the instruction described by Ginsburg-Block and Fantuzzo.

Vermont Mathematics Portfolio Assessment

When the Green Mountain Challenge was issued: "No Exceptions, No Excuses" by the Vermont State Board of Education (1983) a commitment was made to insure that all students would have very high skills. The Vermont State Board of Education set four primary goals for its educational system: produce well-rounded individuals and citizens, restructure schools to support very high performance for all students, develop the best teachers and administrators in the nation, and create partnerships to support education. After the challenge was issued, the investigation into mathematics instruction and the potential for using portfolios as an assessment tool began (Vermont Mathematics Resource Book, 1991). Vermont classroom teachers in collaboration with the Vermont Department of Education explored best instructional practices, and this work led to the creation of the mathematics portfolio assessment process. The group determined that an assessment process was needed so students could demonstrate high levels of skill in complex problem solving and written communication of their understanding of mathematics. The Vermont mathematics portfolio assessment process includes two components, problem solving and communication. This decision paralleled early work in the Vermont Framework of standards and was heavily influenced by the NCTM standards (1989).

The Vermont State Board of Education adopted a comprehensive assessment system in November 1996. The components included student portfolios in writing and mathematics and standards based standardized tests that were administered in the spring.
The student portfolio system required a stratified random sample of mathematics work from all students that was centrally scored with the Vermont rubrics. The portfolio pieces were submitted to the Vermont Department of Education on alternative years. At the local level the state strongly recommended that schools score all students’ portfolios. Schools that received Title I funding were mandated to score all students’ portfolios following the development of an implementation plan. Schools were given three years to develop the plans. Two-thirds of Vermont schools are eligible for Title I funding. The portfolio scores can be used to define “Adequate Yearly Progress” a requirement for Title I funding. In 1996 87% of Vermont schools that have grade 4 students submitted mathematics portfolios for statewide scoring. The portfolios submitted represented 20% of the students in each school. In 1996 teachers at 91 schools of the 350 schools participated in local scoring that year (Vermont Department of Education, 1996). When a school participated in local scoring, 100% of student portfolios are scored.

Additional support for the portfolio assessment process occurred in September 1997 when the state legislative body passed The Equal Educational Opportunity Act.

It is the policy of the state that all Vermont children will be afforded educational opportunities which are substantially equal although educational programs may vary from district to district (Equal Educational Opportunity Act, 1997).

The Act required schools to collect evidence of student progress toward meeting the standards in the Vermont Framework of Standards and Learning Opportunities (1996).
Mathematics portfolios can provide one source of evidence of student progress towards meeting the standards.

The crafters of Act 60 included a requirement for schools to set clear expectations for student performance. All students must show continuous progress by some measure. State mandated tests are one source, portfolios are another, and school districts can develop local assessment plans that will provide data of continuous improvement. School districts and the teachers must use the standards in the Vermont Framework of Standards and Learning Opportunities (1996) as a basis for instruction.

Teachers and school districts were provided with support and instruction from the Vermont Department of Education and The Vermont Institute of Science, Mathematics and Technology (VISMT). Resources were allocated by VISMT to review content specific materials and make suggestions to school districts as to which curriculum materials most closely matched the Vermont Framework of Standards (VISMT, 1998-99). When the curriculum reviews were completed, a suggested materials list was provided to school districts so they could select standards-based articulated curricula.

The requirements in Act 60 included an annual report to the community of the progress students made. Each school district is required to develop an Action Plan that uses the data collected from state mandated assessments, portfolios and local assessment instruments. Using the available data, schools must set goals for improved student performance. The plans must be reviewed annually, using the new data. A new Action Plan is then written that details how students will show continuous improvement (Equal Educational Opportunity Act, 1997).

The Act required the Department of Education to develop specific standards for
all schools in the state. School approval was to be granted based on student performance. The School Quality Standards were developed and approved (16 V.S.A., 1999).

Beginning in school year 1998-1999, each school had to adopt and implement a system to ensure continuous improvement in student performance. The following actions are required.

(a) review and analyze student performance data and other related information to determine its direction for the future, including changes and additions to its conditions, practices and resources,
(b) incorporate such direction into the annual revision, when appropriate, of the school’s action plan,
(c) implement the action plan in order to improve student performance,
(d) assess student performance, and
(e) report results to the public. (Vermont Department of Education, 16 V.S.A., 2123.1, 1999)

Schools that did not meet the criteria outlined in the Act were identified for technical assistance and provided funding from Goals 2000. The schools identified for technical assistance were listed in the local newspapers. The test scores from the New Standards Reference Exam, the Developmental Reading Assessment and the Vermont science assessment for all schools were made available on the Department of Education WEB site, in publications from the Department of Education and in the local newspapers. The pressure on schools to perform was significant. In addition to the listed requirements,
all students who graduate in the year 2005 must have evidence that they have met all the standards in the Vermont Framework although the method of assessment was undefined.

The legislature and the Vermont Department of Education published assessment results so the public would have information about student performance and efforts in their schools to produce discernible student learning. Students in Vermont are currently assessed most frequently at grades 4 and 8. The use of portfolios as an assessment tool in the United States and in general has increased each year as authentic assessment has gained support as a source of evidence of what students know and are able to demonstrate (Ryan & Miyasaka, 1995). The scoring instruments called rubrics use set standards for student performance. The addition of portfolios as an assessment tool in Vermont is in line with the increased use of the portfolio across the United States.

Assessing student work using rubrics led to a large-scale attempt to standardize scoring in the New Standards Project (Resnick & Resnick, 1993). This type of assessment process is similar to the Vermont portfolio process. 114 teachers of English/language arts and mathematics from 23 states came together to refine rubrics and procedures, and score student responses from the spring field test of mathematics and English/language arts performance tasks. The teachers used samples of student work that reflected specific degrees of quality. The samples called exemplars or benchmarks were used in the teachers’ training process.

The New Standards Project (Resnick & Resnick, 1993) was conducted at Big Sky, Montana. The project was an attempt to create a state and district assessment system that would further educational reform in mathematics and English/language arts. Data for the teachers’ training was gathered from an assessment of close to 10,000 grade 4 students.
The students completed an assessment in mathematics and English/language arts that included performance tasks that would be scored by teachers during the training at Big Sky.

Part of the teachers’ work included refining the rubric that would be used to assess student responses to performance tasks. Refining the rubric helped to develop clarifying procedures for scoring student work from the assessment. All teachers received training in the use of the rubric. The training for mathematics teachers was more rigorous than the training for the teachers in the English/language arts group. The mathematics teachers were given continuous feedback. A calibration process was included in the training so mathematics teachers could compare their scores to benchmarked pieces. The training process at Big Sky was similar to the network meetings and calibration sessions held throughout Vermont each school year (Vermont Department of Education, 1997). However, Vermont teachers developed the scoring rubric and conduct the training sessions. The teachers who participated in the Big Sky training used the assessment tools provided by the project developers.

When the training sessions at Big Sky ended, teachers worked independently. Individual teachers scored student work from the assessment. Up to 15% of the papers were double-scored, that is a second person scored the same piece. The scores from the pieces that were double-scored were compared to each other to check for reliability between scorers (Resnick & Resnick, 1993). The pilot project results suggested that refinement and revision of tasks and rubrics was needed and that training scorers was of significant importance and not an easy process. The complexity of developing a rubric that can measure student understanding was the focus of the researchers McTighe and Wiggins.
The grade 4 students in Vermont solve complex problems and communicate their solutions that are collected in a portfolio. Teachers score student work using a standardized rubric and participate in training session to insure scoring accuracy. The Vermont portfolio approach is based on at least the following assumptions (a) young children can successfully participate in problem solving activities in mathematics, (b) the students can solve the mathematics problems in more than one valid way, (c) when students communicate their solutions to complex mathematical problems they become mathematically powerful, and (d) standards-based instruction provides students with the learning opportunities to demonstrate what they know and can do. Several studies supply support for the assumptions including the connection between standards-based instruction as defined in the Vermont Framework (1996) and the NCTM standards (1989) and the
portfolio assessment process.

Reform Based Teaching

The National Council of Teachers of Mathematics focused their work for the past decade on the improvement of teaching and student learning of mathematics. The NCTM revised standards document that included updates to reflect current instructional practice was released in April 2000. The standards were intended as guidelines to be used by classroom teachers who were striving for excellence in mathematics education. The document included recommendations about what mathematics students should learn, what classroom practice should be used, and what guidelines can be used to judge students' performance, as well as evaluation of the effectiveness of mathematics programs.

A publication of the NCTM, News Bulletin, (Tunis, Ed., December 1999) offered answers to frequently asked questions about the standards and their application to classroom instruction. The standards provided a framework for teaching, learning and assessing mathematics. NCTM research (Commission on Standards for School Mathematics, 1995) showed that students can learn more mathematics when teachers offered instruction that required problem solving and explanations of solutions. Standards-based instruction incorporated the use of reasoning and communication strategies by students to learn the mathematics.

The early research into the construction of mathematical understanding by students used the work of Piaget and von Glaserfeld as a theoretical base. In one such early study a classroom teacher and her grade 2 students agreed to work with a research group. The researchers wanted to discover the ways in which children construct mathematical

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knowledge. The students would work in small groups and explaining solutions to the class. The researchers (Cobb, Wood, & Yackel, 1990) videotaped the classroom during mathematics instruction. The children were presented with problems that had multiple solutions. The children were allowed to use their own repertoire of self-generated algorithms and problem solving strategies. During the research study, mathematics instruction changed. The research team charted the change from the teacher-centered classroom where she was the expert at the beginning of the study to a classroom where the students constructed meaning and shared their findings with their classmates and the teacher facilitated the student learning. The students interacted with each other and negotiated for mathematical meaning. The findings of this study indicate that even young children can solve complex problems similar to those included in the Vermont portfolio process.

Vermont students communicate their solutions to complex problems similar to the experiences of the children in the Campbell and Johnson (1995) study. Exploration into the thinking processes of primary students formed the basis of the inquiry conducted by Campbell and Johnson (1995). Students came to school with a variety of background knowledge, but they had the capacity to learn mathematics. The elementary school was the setting where young children confront most of their formal mathematical knowledge. Decisions about the mathematics curriculum and how the school will be organized for mathematics instruction had a critical impact on the mathematical knowledge base children will develop. A mathematics curriculum that encouraged children to construct mathematical knowledge empowered children to think mathematically. The curriculum must allow for multiple entry points so that more children can have the opportunity to
build mathematical competence (Campbell & Johnson, 1995). The traditional curriculums as defined by Campbell & Johnson (1995) that had a list of prerequisite skills moved some students forward, but another remedial track was created for students who did not fit into the set program.

The National Research Council (1989) suggested that if all students were to learn mathematics at the high level recommended by the NCTM, then curriculum must be rethought. A problem solving based curriculum that offered students many opportunities to construct mathematical knowledge will be essential. Children must “construct their own mathematical understanding” (National Research Council, 1989). Word problems would be introduced as children were gaining computational skills, not after they have learned all the basic facts. Two first-grade children in the Campbell & Johnson study (1995) offered the following solutions.

**Word Problem**

Lee has 15 baseball cards. David has 9 baseball cards. How many more baseball cards does Lee have than David does?

“Marcus: Lee has how many, 15?
Teacher: Fifteen. I’ll tell you the whole story again, okay? Lee has 15 baseball cards. David has 9 baseball cards. How many more baseball cards does Lee have than David does?
Marcus: Six.
Teacher: How did you do that?
Marcus: You have to, you have to start from 9 and count on to, count on to 15
and keep track of what, of what you counted.

Second student responds to the same problem.

Justine: Six.

Teacher: Now how did you do that?

Justine: Well...I thought, um, 15 from 6. Ten plus 5 is 15, and 9 is one less and...

You, you should put one more for the, for the 10 (Campbell & Johnson, 1995, p. 26).

The students' explanations represent two different approaches to solving the same problem. Both solutions are valid. The children were constructing the part-total or part-whole relationships. This was an important step toward thinking of number addition and subtraction as differing conditions that composed one big idea. The children were learning through the use of word problems, not being asked to perform addition and subtraction on work sheets in isolation from meaningful context.

The third assumption is that students can communicate their solutions to complex problems. Student communication of their understanding of mathematics problems was the focus of a study by Reineke (1993), a doctoral student at Michigan State University. He conducted ten weeks of observations of mathematics instruction in a grade 4 classroom. The classroom teacher was exploring the implementation of communicating solutions to mathematical problems with her students. The teacher wanted to know if the students could learn more mathematics if they discussed their processes for solving problems.

The classroom teacher shared her concerns and challenges with the researcher.
during interviews that were held after the lessons. She questioned her own knowledge of mathematics and the value of allowing students to broaden the discussion beyond the lesson of the day. She wanted her students to see the connections between mathematical ideas or at least look for connections. Both the teacher and the students learned more about communicating mathematically during the lessons observed by the researcher (Reineke, 1993).

Three lessons were analyzed in detail. The third lesson showed an evolution in the classroom process. The students did explain their thinking. The discussion focussed on the lesson and the students shared more than one option for solving the problem. The class was engaged in mathematical conversations about their thinking. The teacher had reached one of her goals for the students, communicating mathematically. Students in Vermont communicate mathematically each time they solve a portfolio problem. The students have the opportunity to construct mathematical knowledge and become more mathematically powerful.

Instruction

A second component of the Vermont portfolio process required teacher evaluation of their instructional practice. The underlying assumptions for instructional practices that support the portfolio process include (a) teaching as modeled by Dwight Cooley (b) all students can learn complex mathematics, and (c) students must engage in worthwhile mathematical tasks.

In 1995 May & Haugen published a study called *A Fourth Grade Math Lesson* with Dwight Cooley. The series of videotapes show students applying knowledge as the teacher guides their work. The videotapes can be used to help teachers integrate
standards-based instruction into their classrooms. Central Michigan University in collaboration with the North Central Regional Educational Laboratory (NCREL) collected data using video tapes of the instructional practices of Dwight Cooley in his grade four classroom. The videotapes are available from actual classroom lessons for other educators to use as part of an ongoing professional development program.

Dwight Cooley taught at the Alice Carlson Applied Learning Center in Fort Worth, Texas. The staff and students at the school assisted in the collection of the information about the instructional practices for grade 4 mathematics. Dr. Bill Leibfritz, Professor of Mathematics Education along with the NCREL team gathered and analyzed the videotapes made during mathematics instruction. The students worked in heterogeneous groups and students had a wide range of skills. The teacher proceeded through the lesson while checking for student understanding at each stage of the process. He worked to make certain that all students could think mathematically about perimeter and solve the problem of fencing to surround a swimming pool. The curriculum was project based with many opportunities for students to use real life situations as recommended by the NCTM standards (1989).

The lessons presented by Cooley included questioning techniques that allowed the students to explain their understanding of the material. The questions gave students an opportunity to make connections to the real world. The students offered suggestions and included an explanation of their reasoning when they spoke. The teacher directed the students to work in small groups to solve the problem presented to them in the task. Each group member had a responsibility, conditions reflective of the work place. The lesson gave the students many opportunities to work toward a solution to the problem and to
communicate their thinking (May & Haugen, 1995). This type of instruction is central to the portfolio process.

Additional information about instructional practices was supplied by the study of Darch (1984). Concern for poor student performance on the National Assessment of Educational Progress specifically in the area of problem solving led to the research study conducted by Darch (1984). He compared student performance after two different types of instruction, traditional skill-driven instruction to problem solving focused instruction. The teachers of the control groups followed the instructions provided in the state accepted basal arithmetic programs. Scott, Foresman Company, published one of the basal series. The experimental groups were given instruction in an explicit method for problem solving.

Students were selected for the experimental group if they failed the pretest in solving story problems. The experimental groups were taught to solve problems using an instructional strategy called explicit translation strategy. The students were given lessons to analyze the language in the problems to determine the mathematical function to use to find a solution. Both the groups using the basal and the experimental groups were given extended practice for mastery. A posttest and a maintenance test administered ten days later showed greater success in problem solving by the students in the experimental group.

The students had a concrete tool for solving story problems. The basal texts included examples that teach more generalized problem solving, not the specific strategies taught to the experimental group. Many of the teaching procedures are geared to encouraging the students to offer their own solutions and to discuss other proposed solutions. Teachers intervened in cases of failure of students to translate the problem into the correct mathematical form. The students who failed using the basal instructional program
demonstrated greater success after they were given instruction using the explicit translation strategy. The increased opportunities for students to solve problems are central to the Vermont portfolio process. All students can succeed with this type of learning opportunity.

A research and development project designed by Lampert (1990) attempted to look at whether and how it might be possible to bring the practice of knowing mathematics into the classroom. She wanted her students to develop an understanding of mathematics from the perspective of a mathematician within the discipline. She deliberately altered the roles and responsibilities of the teacher and students so that discourse about mathematics could occur.

In traditional classrooms Lampert's observations of grade 4 and grade 5 where mathematics was taught reflected a structure that required students to find the one right answer. Mathematics was associated with certainty: knowing it, with being able to get the right answer quickly. Students were expected to do mathematics following rules laid down by the teacher. Students needed to learn the rules, apply those rules and then check with the teacher for validation of their answer. The mathematics teacher held the truth. Students did not discuss their thinking or share their solutions. Lampert decided to teach her students in a way that matched the discussions conducted by mathematicians who were working in the field. Students would be given opportunities to explain their understanding of the mathematics.

Lampert collected data from teaching fourth and fifth grade mathematics for six years. She structured her classroom so students could participate in a discussion of their thinking about mathematics. Students made assumptions, tested their ideas and made
revisions. A discourse for thinking mathematically was created. She viewed her role as that of a dancer. She held the knowledge and at times demonstrated. She modeled the knowledge and some times learned with the students. At the conclusion of the school year her students did act differently toward mathematical knowledge. They were able to demonstrate their knowledge of mathematics through their discussions. They had learned mathematics outside of the conventional classroom structure.

In contrast to Lampert’s work, Prevost (1996) conducted research in mathematics classrooms where traditional instruction occurred and the teacher was the holder of the mathematical knowledge. The teachers in the traditional mathematics classrooms that were observed by Prevost (1996) followed the same routine each day. First, answers were given for the previous day’s assignment. The teacher or a student worked the solutions to the more difficult problems at the chalkboard. A brief explanation was given of the new material, and problems were assigned for the next day. Some days no explanation was given for new material. The remainder of the class was devoted to working on homework while the teacher moved about the room answering questions. Mathematics instruction of this type has left students without the strategies for answering complex problems. The students did not have opportunities to explain their solutions that helped them learn the mathematics.

A new view of teaching mathematics emerged from the ideas of Constructivism (Piaget, 1972) and the reform leaders in mathematics education. Teachers were no longer seen as dispensers of disconnected knowledge in the form of facts and procedures but were facilitators of student inquiry and thinking (Prevost, 1996). The instructional model required students to develop mathematical understanding as a result of concept
construction and active interpretation, rather than the accumulation of received items of information.

The work of Lappan & Briars and Romberg synthesize the underlying assumptions for this study that a shift in instructional practice must occur if students are to become complex problem solvers and mathematical communicators. The vision of mathematics instruction for the twenty-first century centered on the notion that students must be asked to participate in worthwhile mathematical tasks. The students must see the connection of the task to real things. A problem that asked students to ascertain the value of the different sizes of pizza would be engaging while they explored circles, area and perimeter. A second important component of the instruction required discourse between students about their understanding of the mathematics with the teacher. The classroom must be a place for representing ideas; thinking out loud, agreeing and disagreeing as the group strive to make sense of the mathematics (Lappan & Briars, 1995). The teacher no longer held all the mathematical knowledge, it was constructed by the students, each with his/her own understanding (Romberg, 1992).

Curriculum

If students are to have the opportunities to solve complex problems and communicate solutions then it can be assumed that the curriculums used for instruction must be reform-based. Thus current research reported by mathematicians in the field implied that no amount of teacher explanation would guarantee student understanding. The students must construct knowledge and interpret its meaning. In order for the student learning to happen, mathematics instruction must include reasoning, problem solving,
creating evidence and making connections (National Council of Teachers of Mathematics, Professional Standards for Teaching Mathematics, 1991). Mathematics teachers can choose from a wide variety of materials developed that align with the standards articulated by the National Council of Teachers of Mathematics (NCTM, 1995). After thorough review of existing curriculums by a panel of experts appointed by the Office of Educational Research and Improvement (United States Department of Education, 1997) several programs that aligned with the NCTM standards were recommended. The programs identified as exemplary included Interactive Mathematics Program (1994) for high school students, Connected Mathematics Project (1995) for middle school and Everyday Mathematics (1994) for elementary school. The results of research studies for each program including students’ performance on high stakes assessments were used during the curriculum reviews. All the schools in the current study used a school-wide adopted curriculum; Everyday Math was adopted in 9 of the 19 schools that participated in the study.

The reform-based curriculum developed at the University of Chicago School Mathematics Project (UCSMP, 1997) attempted to meet the vision of the National Council of Teachers of Mathematics. The curriculum developed included instruction where students could reason and create their own understanding of mathematics. The UCSMP curriculum called Everyday Mathematics required students to work in groups, explore mathematics in real-life contexts, use manipulatives and other mathematical tools. The program began with implementation in kindergarten and continued through grade six. Students discussed their processes for solving problems, shared their ideas and their thinking. Problems were nearly always application-based and never presented as sets of
symbolic problems. In a second grade lesson students were given a picture depicting various animals. The heights and lengths of the animals were included in the picture. Students worked in small groups to construct number stories that compared the animal heights and then found a solution method. In the follow-up discussion, students shared their stories and solution procedures with the whole class. Students worked together in small groups to construct mathematical understanding.

A wider variety of mathematics was explored in reform curricula; less time was spent on computation and other number skills. Although UCSMP curricula attempted to implement the ideas of the reform movement, there were those who questioned the depth of the mathematics students learned (Ginsburg-Block & Fantuzzo, 1998). The critics of the reform movement cited that learning basic skills and computation by students was deficient. Most states required students to take some type of mathematics test, so the performance of students on these high-stakes assessments was a crucial issue in the reform movement. The question to be answered is if students are taught using a reform-based curriculum, does their performance improve on the high stakes assessments.

A study was designed by Carroll (1997) to review students' performance on the Illinois Goal Assessment Program (IGAP). The test was fairly traditional for grade three. Students were allowed 80 minutes to answer 60 multiple choice, single-answer items on the 1993 assessment. There were no performance-based items and students were not allowed to use calculators or other tools (Illinois State Board of Education, 1993). Students using the UCSMP were accustomed to open-ended problems, group work and the use of calculators and manipulatives, but the IGAP test did incorporate ideas of the reform initiatives. Students were assessed in six mathematical strands: number concepts
and skills, measurement, algebra, geometry, data, and estimation. The results grouped students in three categories: not meeting goals (algorithmic thinking); meeting goals; exceeding goals (extending mathematics to solve problems in daily life). Although the test format was different from the UCSMP curriculum, the mathematical content strands and goals were similar to those addressed in the curriculum.

The test results were reported at the school level, so the researcher selected third grade classes in Illinois that used the UCSMP curriculum. No public schools in Chicago were using the curriculum at third grade so those scores were used for comparison. The IGPA reported a school score that ranged from 0 to 500. Along with this score, a confidence band was provided for each school and district to allow comparisons between schools and districts from previous years (Illinois State Board of Education, 1993).

The IGAP mathematics scores for the UCSMP third-grade classes ranged from 276 to 423, with a median class score of 332 (mean school score 337). This compares favorable to both the state (268) and the suburban Cook County (295) mean scores. All 26 UCSMP schools scored well above the state score and only three scored below the suburban Cook County score. Moreover, when only the 14 schools where the current third-graders had been in the curriculum since kindergarten are considered, the scores were even higher, ranging from 310 to 423, with a median score of 343 (mean school score 351), 75 points above the state score. These results suggest a positive longitudinal effect of the curriculum (Carroll, 1997, p. 239).
The students demonstrated that they were capable of learning a larger domain of mathematics using the UCSMP curriculum without losing ground in more traditional skills (Carroll, 1997).

With the use of new curriculums and a shift in instructional practices, new ways for assessing students were developed. The new assessments included collections of student performances. The effort by reform-based practitioners to develop an alternative assessment of student knowledge when mathematics was taught using complex problems and group work supported the growth of the portfolio process in Vermont. The collections of student performances vary in contents, but the inclusion of student selected work was a common criteria. The dramatic changes in mathematics instruction that required students to think, to be comfortable with problem solving, to question and formulate hypothesis, and to investigate offered fertile opportunities for portfolios of student work that demonstrated mathematical thinking (Romberg, 1992). The portfolios could become a collection of a student's mathematical knowledge with written explanations of their solutions to complex problems.

Assessment of Student Knowledge through Portfolios

Performance pieces in a portfolio provided an alternative to standardized assessment for many writing teachers. The teachers in collaboration with students set the criteria for developing a personal portfolio (Case, 1994). In most instances students chose the pieces of writing to be included in the portfolio or they may have included all writing to demonstrate progress over time. Students are provided with criteria for creating a piece of writing and the rubric that will be used to assess that writing. The work in the
portfolio can be the evidence that a student met state standards or achieved results defined by the school district.

Rief (1992) collected data about student writing and reported that it provided "rich evidence of what they (the students) were able to do and how they were able to do it." Students were given an opportunity to review work and evaluate its quality. The students became independent writers who constantly engaged in self-evaluation. The use of portfolios in the writing classroom provided the students with an avenue to set goals for their own learning. The growth of individual students occurred over time not at a single setting. The same possibility for students to show growth in their mathematical knowledge could be contained in a portfolio. The Vermont portfolio process was developed to provide evidence of students' mathematical knowledge. The current study explored teacher participation in the portfolio assessment process in Vermont.

The possibility that a portfolio could contain evidence of student knowledge was the assumption made in several studies. The use of a portfolio is central to the assessment system in Kentucky, Vermont and for several schools that are affiliated with the Coalition of Essential Schools. Supporters of a portfolio process are staunch in their belief that it is the best evidence of student learning.

Educators in Weld County School District in Colorado decided to systematically raise overall achievement. They developed a system that required students to demonstrate competency in writing, reading and mathematics prior to graduation. Similar to the portfolio process a writing assessment was required of students. Each month reports were given to the students. When educators compared the monthly report, students showed a significant increase in their writing performance (Schmoker, 1996). The feedback to the
students from the assessments was critical to the improvement process. After one year of using the writing rubric an outside assessor reported “remarkable improvements” had occurred in the student writing (Schmoker, 1996).

Teachers in Kentucky began using portfolios to determine the academic strengths and weaknesses of individual students. The use of portfolios grew from the Kentucky Educational Reform Act of 1992 that mandated performance-based assessment. The mathematics portfolio for grade 4 students included a table of contents, a letter to the reviewer, and five to seven entries that reflected the students’ best work in the classroom throughout the year. The portfolios were scored by the classroom teacher or by scoring teams at the school (Saylor & Overton, 1993). Students were encouraged to reevaluate their portfolios so that their best work was represented. The mathematics portfolio from a Vermont student would include a letter to the reviewer, 5-7 of student selected best pieces from specific types of problems. The portfolio contents are very similar.

Advocates of a portfolio process described similar purposes for continued use. When portfolios were used as collections of student work selected by the student to represent best efforts, useful information became available to teachers and administrators. The portfolios could be reviewed for evidence of quality teaching and improved learning opportunities for students. Co-directors Resnick and Tucker (1993) of the New Standards Project were developing a new assessment system to support world-class standards of performance for all students that included portfolios as one component. Seventeen states have partnered with them including Kentucky and Vermont (1993). Teachers evaluated assessment strategies as they worked to link the learning and evaluation process. Karp and Huinker (1997) believed that portfolios could be change
agents for assessment of students as individuals. The portfolio could be a personal reflection of a student’s work over time that demonstrated a student’s understanding, beliefs, attitudes, and growth.

Adams (1998) described assessment strategies for teachers to use so that a broader understanding of what a child knows and can do would occur. The strategies included the use of portfolios. She suggested that teachers could develop a more comprehensive understanding of student knowledge by including alternative assessment strategies. Traditional paper and pencil tests offered quantitative information but did not constitute a totality of assessment by themselves. Adams developed criteria for a student portfolio that was included in her geometry classes.

A portfolio of student work in geometry could contain the following information:

- Initial sketches and records of identification of designated plane figures from the time of introduction to the concepts
- Interim sketches and records of identification of the plane figures produced during in-depth learning of the concepts
- Final sketches and records of identification of the plane figures created at the end of instruction on the concepts
- Construction of models that represent plane figures
- Written descriptions of plane figures
- Descriptions of how plane figures found in the child’s environment are used
- Classifications of plane figures into groups determined by the child
- Records of investigations, explorations and discussions of geometry concepts
- Records of geometry terms and definitions learned and applied
A teacher could make valid inferences about a student’s understanding of concepts and skills from examining the work samples included in the portfolio. The included materials could offer teachers information about content understanding of students and instructional methodology. Combining the review of student work with reflective practice might aid in the improvement of mathematics teaching and learning.

The mathematics rubric used by Kentucky teachers placed emphasis on students’ abilities to problem-solve, reason, communicate mathematically, integrate and connect core concepts, and use tools appropriately. Teachers and students could use these rubrics as a regular part of instruction and then the criteria become the standards for student learning (Stroble, 1993). Benchmarked pieces were provided for teachers to use with their students in the classroom so that the vision of the education reform act could help lead all students to high levels of success.

An assessment project designed by Jorgensen (1996) included the use of student portfolios. The Authentic Assessment for Multiple Users (AAMU) project received support from the National Science Foundation. Jorgensen began with the premise that assessments should support important teaching and important learning. When portfolios were used for assessment there was an implicit expectation that the evidence in the portfolio could be judged against well-articulated standards of quality. There must be common attributes or evidence that the work of a student or the work of a group of students reflected the appropriate standards of quality designed to evaluate the work. Jorgensen designed an assessment model that supported the use of portfolios to
demonstrate what students know and can do. She wanted to determine whether portfolio assessment could be structured to match Cronbach’s definition of measurement. “A test is a systematic procedure for observing behavior and describing it with a numerical or categorical score.”

The teaching guide developed from her work included specific assessment tasks, teacher directions for administration, scoring guides or rubrics, and exemplars of student work. Elementary mathematics teachers could use examples from this work in their classrooms to teach important mathematical concepts.

Classroom teachers interviewed for articles published in the National Association of Secondary School Principals journal (1995) reported increased use of portfolios for assessing mathematical knowledge and understanding. Robinson (1998) documented her use of the portfolio with students in algebra, geometry and pre-calculus. Karp and Huinker provided detailed use of the portfolio and the impact on students. It was described as a rich form of assessment. In addition to the assessment conducted by the teacher, the students who created the portfolios could self-assess and reflect on their learning. Students in the Salt Lake City school district were building portfolios that included evidence that they were meeting the performance results mandated by district officials. After two years the students discussed performance results. They were familiar with the elements of complex thinking and the characteristics of effective communication (Baron, Johnson, & Acor, 1998).

Portfolios were the core document used by students at Central Park East Secondary School to demonstrate that they had met the standards set by the school. Student learning was assessed through performances, demonstrations and exhibitions.
Prior to graduation each student must collect evidence in a portfolio that demonstrated all standards were met. CPESS is a member of the Coalition of Essential Schools. Students who attended the Bronx New School and Hodgson Vocational Technical High School also were required to build portfolios that demonstrated their learning (Darling-Hammond, Ancess, Falk, 1995). Students used the portfolios in the college admissions process and to secure employment. They had evidence that they were complex thinkers and self-directed learners, qualities that were desired by the public sector (Wiggins, 1993).

The decision by a team of Vermont educators to use alternative assessment tools to reflect student knowledge of mathematics led to the development of the mathematics portfolio assessment process (Vermont Department of Education, 1997). Students were given complex problems to solve and they were required to include a written explanation of the solution. The Vermont requirement for grade 4 students to assemble mathematics portfolios of their solutions to complex problems continued to be an important component of the state assessment system (Vermont Department of Education, 1997).

In the spring of 1999 the Vermont Department of Education distributed a survey to all grade 4 teachers. Teachers were asked to report about their preparation to teach mathematics, years of teaching experience, years teaching at grade 4 and professional development training during the past five years. Teachers reported curriculum materials in use including supplementary materials. Questions about instructional practices that supported standards-based instruction and the inclusion of portfolio problems were included in the survey. The strong commitment to the use of portfolios was reflected in the survey questions.

The results of the survey were published and distributed to superintendents,
principals, school boards and the state legislature. The Department of Education published all findings for public review. The commitment to Vermont children was the lead statement in the published articles and reminded readers that meeting and exceeding rigorous standards would take intensive ongoing work by students and educators. Assistance with instruction was offered to all school districts and curriculum materials were recommended that aligned with the state framework of standards. All schools were encouraged to use the identified curriculum materials and to provide standards-based instruction so that the students would be able to meet the standards in the Vermont Framework of Standards and Learning Opportunities (1996). Standards-based instruction is synonymous with reform-based teaching in Vermont. All the efforts were intended to improve student performance on the assessments that are mandated in the Vermont Comprehensive Assessment System (1997).

**High Stakes Performance Assessment**

Students in the United States are assessed with a variety of testing instruments that are intended to provide documentation of their achievement. Some states including Massachusetts and New York have set high levels of performance as a requirement for graduation. Students in Vermont must have evidence of meeting all standards in the Vermont Framework of Standards to graduate in 2005. Kentucky has high stakes testing that includes student portfolios. National testing continued in a study conducted by the Third International Mathematics and Science Study (1997).

The Vermont Comprehensive Assessment System (1997) included assessment opportunities for all students in Vermont. Every student must show evidence of
continuous progress toward meeting or exceeding the standards in the state Framework of Standards (1996). The first assessment was administered at the end of Grade 2, the Developmental Reading Assessment. The New Standards Reference Exam was given to Grade 4, 8, & 10 students in English/Language Arts and Mathematics. Science was assessed at Grades 6 & 11 using a tool developed by teachers in Vermont. Social Studies will be assessed at Grades 6, 9, & 11 in the near future using a test developed by a team of Vermont educators. Students in grades 4, 8, & 10 participated in the mathematics portfolio process. The portfolios were collected and scored on alternate years. Students in grades 5 & 8 submitted writing portfolios for scoring on the opposite years from the mathematics portfolios.

The results of the assessments were sent to individual schools and superintendents’ offices for each assessment instrument. Reports for individual students were prepared to be sent home to parents by the schools. The results for all schools were published in local newspapers and the Department of Education has a WEB site where every school is listed with the assessment results. A statewide report or summary of assessment results for the 1997-1998, 1998-1999, & 1999-2000 school years included the number of students tested. The number of students assessed each year appears in Table 1.

<table>
<thead>
<tr>
<th>Assessment Year</th>
<th>Number of students assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997-1998</td>
<td>7,679</td>
</tr>
<tr>
<td>1998-1999</td>
<td>7,881</td>
</tr>
<tr>
<td>1999-2000</td>
<td>7,605</td>
</tr>
</tbody>
</table>

Table 1

Total Students Assessed

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The report included the percent of students who achieved the standard or achieved the standard with honors in each of the assessments for all grade 4 students. The student performance results for the New Standards Reference Exam (NSRE) in grade 4 mathematics are listed in the chart below. The NSRE tests student knowledge in mathematical concepts, skills and problem solving. The results of students' performances are reported in relation to the standards; that is, achieved the standard with honors, achieved the standard, below the standard, or no evidence of achieving the standard.

Table 2

Statewide Results for the New Standards Reference Exam

<table>
<thead>
<tr>
<th>Area of Assessment</th>
<th>Assessment Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts</td>
<td>32%</td>
</tr>
<tr>
<td>Skills</td>
<td>62%</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>29%</td>
</tr>
</tbody>
</table>

Note: Percent of students in Grade 4 who scored in the highest two performance levels: achieving the standard or achieving the standard with honors.

The assessment results were available to schools in the fall; this was the time for the Action Planning Teams to resume their work. The teams by law were to review the assessment scores and to revise the action plan for the next year. The Action Plans must be approved by the local school boards and submitted to the Department of Education (DOE). School assessment scores were reviewed by the DOE each year to determine if the schools were making adequate progress. A school that did not show progress was
identified for technical assistance by the department. The names of identified schools were published in the local newspapers.

The Vermont Institute for Science, Math and Technology (VISMT) published a booklet entitled *Raising Scores in Problem Solving* (1998-1999). A comparison between the mathematics portfolio process and the New Standards Reference Exam was made to help educators understand the relationship. The same content and intent were shared with different processes. Training sessions for using portfolios as a regular part of instruction were available across the state. Teacher associates who work for VISMT were available each year to help educators learn about standards-based instruction, curriculum that was standards-based and inclusion of the portfolio process. There was an unfaltering belief that raising scores in problem solving would occur as a result of the integration of problem solving into the mathematics classroom (VISMT, 1999).

The national attention to student performance continued when the Third International Mathematics and Science Study (TIMSS) was conducted by the United States Department of Education (1997). Students from 26 countries participated in the testing program. Teachers were given a questionnaire to complete about their teaching. The results were analyzed by the National Center for Educational Statistics. The study results gave some indication about student performance and of the schooling practices in the United States compared to the practices in the other nations that participated. The report suggested caution with the results since it was early in the data analysis process. The TIMSS report data might be used to improve the quality of education received by primary students.

The study was conducted with the hope to improve teaching, curricula and student
achievement in states and local communities. The reports were available along with a multi-media resource kit to assist with the school improvement process. In all participating countries, students in both public and private schools were administered the TIMSS test. Testing occurred 2-3 months before the end of the 1994-1995 school year. Students with special needs and disabilities that would make it difficult for them to take the test were excluded from the assessment. All testing in the United States was done in English. The assessment instrument required one and one-half hours for administration. Students had to answer both multiple choice and free-response items. A small number of students also completed hands-on performance tasks.

The fourth-grade students in the United States who were assessed in mathematics scored above average in five of the six categories tested. Student performance was below average in measurement, estimation, and number sense. However, scores were above average in whole numbers, fractions and proportionality; data representation, analysis, and probability; geometry; and patterns, relations, and functions. Nine percent of the students would qualify for an international mathematics talent search and rank among the world's top ten percent.

Beginning data analysis did not provide strong evidence of factors that may be related to performance. The curriculum in the United States was not determined at the national level, but it was in 18 of the 26 countries that participated in the study. Fourth grade students in the United States spent more time learning mathematics each week, but four of the seven nations that outperformed us spent less time in class. Students in three of the countries that outperformed students in the United States spent less time each week on homework assignments.
Information about teaching was collected in a teacher questionnaire. The data suggested that organization for instruction in United States fourth-grade classrooms was similar to that of other countries. Teachers from all participating countries reported four major areas that limited their teaching. The first area, different academic abilities was reported by 61% of the teachers in other countries as a major limitation. This international average was far above the 41% reported by teachers in the United States. High student/teacher ratio, equipment shortage, and disruptive students were the other three categories that teachers indicated limited their teaching time. The international average was higher in each category than the report provided by teachers in the United States. Further analysis of the data will be conducted in an effort to discover why some countries outdistance our students when scores were compared. The only factor that was different from the international average was the amount of time United States fourth grade students watched television. Thirty-two percent of United States students reported watching three hours or more of television on a normal school day. This was higher than the international average of twenty-five percent. The other international averages on the items discussed were similar or there was little difference when compared. The TIMSS report did not find similar educational characteristics present in every high-performing country. If anything, the report suggests that there may be multiple recipes for excellence (1997). The results of the study were provided to the public; however, the impact of the assessment on student performance or instructional practice remained unknown.

Shepard and Dougherty (1991) developed a study to explore the impact high stakes assessment has on instructional practice. Two large school districts participated in the study where high stakes testing was used. Prior to standards movement traditionally

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standardized tests of achievement were used to report student progress to parents and in some cases to monitor district trends across the United States. In the past teachers rarely saw the results and if they did, little attention was paid to the test scores. With the addition of standards for student performance becoming the norm in all fifty states (Wiggins, 1991), student assessment or high-stakes testing could influence instructional practices. Shepard and Dougherty (1991) surveyed teachers in two districts where there was agreement that high-stakes testing was a recognized practice. The researchers attempted to discover the influence of the testing on the teaching practices of elementary teachers. Were the pressures to raise test scores associated with instructional changes?

A questionnaire addressing test-preparation practices and the effects of testing on instruction was mailed to principals in two high-stakes school districts. The principals were asked to distribute the questionnaires to all teachers of grades three, five and six along with the stamped envelopes to return the questionnaires to the researchers. The response rate from District A was 37% and the response rate from District B was 44%. The questionnaire was four pages long, divided into specific sections and included two questions that had open-ended responses. The open-ended questions asked teachers to report specific examples of positive or negative influences of standardized tests on their teaching or on students in their classrooms.

The teachers in both districts reported pressure to raise test scores. The greatest pressure to raise scores was from the administration and the school board as reported by 53% of the teachers who responded to the questionnaire. The second source of great pressure was from the newspaper or media. Most teachers did not report feeling pressure from parents or from other teachers.
The teachers reported that there were instructional shifts that occurred because of the testing. Two-thirds to three-quarters of the teachers gave more emphasis to basic skill instruction including vocabulary lists, word recognition skills, and paper and pencil computation than they would have if there were no mandated tests. This finding did not match the results reported by Romberg, Zarinnia & Williams, (1989) where only 30% of the teachers increased their emphasis on basic skills. The Romberg, Zarinnia & Williams results were from a national sample of grade 8 mathematics teachers. The teachers reported that as a result of the testing they had increased paper and pencil computation by 25%. Romberg et al. concluded that instructional changes promoted by the standardized testing were opposite to the kinds of instructional changes sought by the mathematics community and represented in the NCTM Curriculum and Evaluation Standards for School Mathematics (1989).

Teachers also reported in the Shepard & Dougherty study (1991) that they increased student use of manipulatives and project work in mathematics. A clear majority of teachers said that they increased practical thinking activities and practice in divergent problem solving. The testing conducted in District A and District B (Shepard & Dougherty, 1991) only included mathematics and English/Language Arts. The teachers reported changes in instructional practice in those two content areas and a decline in the time spent teaching social studies and science. The test preparation activities were frequent, occurring throughout the school year.

The purpose of the study was to assess the effects of standardized testing on instruction in two high-stakes schools districts. Third, fifth, and sixth grade teachers in approximately 100 schools were surveyed. The limited response rate of 42% prevented the
finding from being generalized to other contexts. However, the public reporting of the test results did create pressures for teachers to change instructional practice. The teachers emphasized basic skill instruction as a result of the standardized tests. These two findings suggest that instruction can be effected by high-stakes testing (Shepard & Dougherty, 1991).

The state of Kentucky has been the site of high stakes performance assessment for the past ten years. Following the ruling by the Kentucky Supreme Court ruled in June 1989 that the public school system in the Commonwealth was unconstitutional, the court directed the General Assembly to establish a more equitable system. The school system was to be monitored on a continuing basis so that the system would be maintained in a constitutional manner. This historic decision was based on evidence presented in Rose v. the Council for Better Education, Inc. (1989). A Task Force on Educational Reform was established as a result of the court order. The Task Force’s recommendations were sent to the General Assembly and formed the basis of the Kentucky Education Reform Act of 1990. One of the most significant components of the Reform Act was the student assessment system. This high stakes assessment program specified that results from the assessments would be used to grant rewards to schools that showed significant improvement and sanctions would be levied against schools that failed to show progress (Guskey, 1994).

Six broad learning goals were developed as part of the reform that identified what all students should know and be able to do (Winograd & Webb, 1994). After the goals were developed, 75 learner outcomes that were specific and measurable were constructed. The combination of the goals and the 75 outcomes provided the basis of the changes in
curriculum and instruction that needed to occur in all schools. One component of the three-phase assessment program was the evaluation of portfolios of students’ work in the areas of writing and mathematics (Guskey, 1994; Stroble, 1993; Saylor & Overton, 1993). The initial response from teachers suggested that they needed time to plan with peers to efficiently use portfolios as an assessment tool. Oldham (1994) suggested that substantial professional development would be necessary for teachers to make the changes required in their instructional practice to effectively implement the portfolio process as an authentic assessment tool in their classrooms. The portfolios must become a part of regular classroom assessment and only long-term professional development could accomplish this objective (Khattri, Kane, & Reeve, 1995). The studies suggested that the work to implement the Kentucky assessment process would require additional teacher training.

The state of Vermont has a comprehensive assessment system that required students to meet standards defined in the state Framework (1996). The mathematics portfolio process is one component of the assessment system. The Department of Education developed an implementation plan for the portfolio assessment process that included ongoing training for teachers. Network meetings and calibration sessions were available in many locations during each school year. Teachers were invited to attend the training sessions that were often scheduled after the regular school day. The Department of Education continued to commit resources including training in mathematics instruction and assessment so teachers could include portfolios as a part of their regular classroom assessment.

Mathematics portfolios were one component of the high stakes assessment system that was an intricate component of the lives of fourth grade teachers in Vermont. Support
for the use of the portfolio assessment process as a means to assisting students to meet or exceed the standards in mathematics problem solving and communication continued from the Department of Education. Curiosity about the instructional practices included in grade 4 classrooms led to the development of the research question. Questions in the survey will ask teachers about their instructional practices and inclusion of the portfolio problems. The extent of teacher participation in the portfolio process will be explored as a possible connection to reform-based teaching methods and standards-based instruction. Data analysis will be used to explore a connection between the level of teacher involvement in the portfolio assessment process and instructional practices for complex problem solving and mathematical communication.

**Rationale for the Study**

The findings from this study could provide information from classroom teachers about the influence portfolio scoring has had on their instructional practice. Questions about the need to score 100% of student portfolios were asked every school year due to the amount of time and resources required for completing the work (Stecher & Hamilton, 1994). The study could shed light on the level of scoring the teachers choose on the years that the portfolios were not submitted. The level of participation for three school years was included in the survey questions.

The assessment process was intended to improve instruction so that students would meet the standards recommended by the National Council of Teachers of Mathematics (Commission on Standards for School Mathematics, 1989) and meet the required standards in the Vermont Framework of Standards and Learning Opportunities.
(1996). Some teachers worried that instruction that emphasized problem solving and mathematical communication took time from teaching basic skills and computation (Koretz, 1994). The survey could provide an indication of the time teachers gave to instruction in problem solving, concepts and basic skills.

The results of the study could provide information from grade four teachers about the impact participation in the portfolio process has had on their mathematics instruction. Teachers will be asked to report on their inclusion of specific instructional strategies that assist students in the portfolio process. The results of the study may give suggestions about the level of involvement in the portfolio assessment process necessary to positively impact mathematics instruction so students’ performances in mathematics reach or exceed the standards.

The review of the literature led to the development of the study into the instructional practices used by teachers. The use of the portfolio process was intended to improve the learning opportunities for students. The study through the use of a survey will question participation in the portfolio process including the level of scoring, the use of specific instructional strategies and the specific mathematics curriculum used to provide instruction. The researcher will attempt to discover if the mathematics instruction provided to grade 4 students is helping them to become complex problems solvers who can communicate their solutions.
CHAPTER III

METHODOLOGY AND PROCEDURES

The study was structured to gather information about the instructional practices used by grade 4 teachers in Rutland County, Vermont. The teachers were asked about their participation in the portfolio training sessions provided by the Vermont Department of Education and the extent to which they scored student mathematics portfolios. This chapter includes information about the portfolio assessment process, specific terms relevant to the study, hypotheses, design of the study, survey instrument, implementation of the survey, and data analysis of the findings.

Research Question

This study was designed to answer the following research question: Is the way in which grade 4 mathematics is taught among Vermont teachers related to their level of involvement in the portfolio assessment process?

The extent to which teachers integrate problem solving and mathematical communication into their instructional practice was assessed using self-report data from a survey of classroom practices. Teachers' use of the scoring guide (rubric) as the tool to evaluate student work in problem solving and mathematical communication was included
in the survey questions.

Vermont's Mathematics Portfolio Assessment Process

The portfolio assessment process was implemented in the 1990-1991 school year as a pilot project. The number of schools that participated in the portfolio assessment process increased each year (Vermont Institute of Science, Mathematics and Technology, 1998-99). The portfolio system became a requirement when the Department of Education included it as one of the components of the comprehensive assessment system (1997).

The teachers of grade 4 students began the process by assigning portfolio problems to their students. The portfolio problems could be completed on a weekly basis, at the completion of an instructional unit or students could work on portfolio problems during independent study times. The students' solutions were placed in individual folders. By the end of the school year students typically had 10 – 20 pieces in the folder. The next step in the process required students to select five to seven solutions that they believe are their “Best Pieces” that would be submitted for scoring. The pieces selected for submission should include solutions to specific types of problems: one puzzle, one investigation, and one application and no more than two pieces from group work. Selection of Best Pieces should include a consultation with the teacher. Teachers should ensure that the pieces selected are indicative of problem solving activities and can be scored. Teachers were required to submit a designated percentage (randomly selected) of student portfolios for scoring by state examiners. All portfolios submitted for scoring included a cover letter to the evaluator that explained why the pieces were selected. If the student's work was selected for scoring, the folder of work was submitted to the Vermont Department of
Education for state scoring.

The classroom teachers could score the students’ solutions as it went into the folder or at the end of the school year. The students could revise the work at any time during the school year prior to submission for state scoring. There is no time limit for completing the problems, however, teachers may give due dates. The level of integration of the portfolio process into the classroom could influence the amount of scoring done by the teacher.

There are three different levels of participation in the scoring process for mathematics portfolios. Teachers in a school may choose not score any of their students’ portfolio pieces and submit the required, randomly selected 20% of the portfolios on alternative years to the state. Teachers can score the randomly selected 20% of student portfolios prior to submission. Teachers may score 100% of their students’ portfolios and submit the randomly selected 20%. The 20% are referred to as the state sample. The 100% are referred to as local scoring or school scoring (Department of Education, 1997).

**Definition of Terms**

Mathematics portfolio: 5-7 student generated solutions to complex problems selected by the student for submission for scoring.

Scoring: Process that evaluates each solution using a standardized rubric

Problem solving: The strategies and skills used to solve the problem, and reasoning that supports the approach including the student’s mathematical work that supports the answer.

Mathematical communication: The use of accurate and appropriate mathematical
vocabulary and mathematical representation in communicating the solution.

Portfolio Scoring Guide: Standardized rubric used by teachers to score grade 4 pieces. The guide has two components, problem solving criteria and communication criteria (see Appendix A). The same guide is used by scorers at the state level.

Network Meetings: Scheduled meetings for teachers to practice scoring student solutions to portfolio problems.

Calibration Sessions: Training sessions for teachers to compare their scoring to state scoring to insure reliability.

Research Hypotheses

1. Teachers who score 100% of student portfolios will tend to use mathematics instruction that maintains elements of problems solving and mathematical communication.

2. Teachers who do not score or only score 20% of student portfolios will not tend to use mathematics instruction that maintains elements of problem solving and mathematical communication.

Study Sample

The grade 4 teachers in Rutland County were asked to participate in a survey that included questions about their mathematics instruction, participation level in the portfolio assessment process, and demographic information. A follow-up telephone survey was conducted with volunteer survey respondents to enrich the data from the survey. The
research design included two independent variables and two dependent variables. The independent variables were level of involvement in scoring and frequency of involvement in the process. The dependent variables were frequency of problem solving opportunities and frequency of mathematical communication (both written and oral).

**Survey Instrument**

A survey instrument was designed with 18 closed response questions, one question to identify the mathematics program used for instruction and one open-ended question requesting a description of mathematics instruction on a typical day. A teacher completing the survey would respond to questions about instructional practice and the level of involvement in the portfolio assessment process for the past three school years. The directions for question number 20 required teachers to write a short narrative about a typical mathematics lesson. At the end of the survey respondents were asked if they would be willing to participate in a follow-up telephone interview. The survey was designed to take less than fifteen minutes to be completed. (During the pilot of the survey, some teachers reported only ten minutes were necessary to answer all questions).

The survey questions were a combination of both new and adapted items from an instrument constructed by the Vermont Department of Education. The instrument constructed by the Department of Education (1998) was titled the Learning Opportunities Survey. All questions were constructed to gather specific information about mathematics instruction and the level of teacher involvement in the portfolio process.

Demographic information was included for gender, years of teaching, years teaching mathematics, enrollment of grade 4 students in the school and average class size.
Two questions were included about teacher participation in the network training sessions and calibration sessions. Portfolio scoring practices for three school years and the reason for the scoring were part of the survey. Information about school Action Plans and the inclusion of a performance goal for mathematics was requested. Teachers were asked about their participation in training in mathematics.

Seven questions with a Likert scale (never, rarely, sometimes, often, always) were included that specifically dealt with instructional practice. Responses for three school years were collected.

Teachers could choose to participate in a telephone interview. The follow-up telephone survey included four questions of original design. The questions used in the telephone survey gave teachers the opportunity to clarify instructional practices used to teach mathematics and learning opportunities given to students in the mathematics classrooms. Teachers were asked if they supplemented the mathematics curriculum and if they reviewed the portfolio scores.

Teachers who were using the portfolio assessment process were asked to review the survey. Formal review of the instrument was conducted to check for internal validity so that data could be analyzed. The first draft of the survey was shared with mathematics teachers at West Rutland School, West Rutland, Vermont and with a Professor of Mathematics at Castleton State College. Feedback was given about the potential for the survey to answer the research question. Many questions were eliminated since the questions would not provide useful data.

After several preliminary revisions, the survey was piloted with nine teachers of mathematics including several grade 4 teachers. Each of the teachers had participated in
the portfolio assessment process and had attended network meetings and calibration sessions. They were asked to complete the survey and to write comments on any question if the language was not clear or if the question did not seem connected to the research question. Additional revisions were made to some questions where language confusion was identified (see Appendix D).

Implementation of Survey

There are 22 elementary schools with grade four students in Rutland County. All schools were invited to participate in the study. Rutland County is a rural area that includes one city; the residents are primarily white. Many towns in the county based on income levels are receiving towns from the school funding formula (Equal Educational Opportunity Act, 1997). To make certain that the correct number of surveys was sent to each school, a student worker from West Rutland School called the elementary schools and asked about the number of grade four teachers. He also asked if teachers at the school locally scored portfolios (100%). The student compiled the data in a spreadsheet.

The researcher made the next contact with the schools in Rutland County that have grade 4 teachers via a telephone call to the school principal. The research project was explained and a request was made for assistance. In many instances a secretary took a message for the principals. In all but one school the principal or secretary agreed to help with the distribution of the survey materials to grade 4 teachers. A follow-up letter and the packets for grade 4 teachers were sent to the principals after the telephone calls were made. The letter to the principal asked that he/she contact grade four teachers and request that they participate in the study.
The materials mailed to the principals included a packet for each grade 4 teacher in the building. The teacher packets included a letter of explanation, the survey, and a stamped, self-addressed return envelope.

Follow-up telephone calls were made to the schools ten days after the materials were mailed. When the second calls were made more principals were reached. Again, all but one agreed to provide assistance. A second copy of the survey and related materials were mailed to schools that had not responded. The return rate of the mailed surveys was 76% (37 of 49). 18 of 37 teachers agreed to the telephone interview.

The teachers who agreed to participate in the telephone interviews were contacted at home. Telephone calls were made late in the afternoon or early evening. Some teachers were reached on Saturday afternoon. Several attempts were made to reach each teacher who agreed to participate in the telephone interview. 12 teachers were contacted.

Data Analysis

The survey data were analyzed to test the two hypotheses. The inquiry was an attempt to discover whether or not teachers who score 100% of their students' portfolios were more likely to use instructional practices that support complex problem solving than their counterparts who participated minimally in the scoring or not at all. Data were analyzed to determine whether or not there was a correlation between the independent and dependent variables; however, any correlation would not necessarily imply a causal relationship.

The data available from the description of a typical lesson are reported along with the mathematics program the teachers used for instruction. Common elements of
mathematics instruction are included in the survey, particularly opportunities for students to solve problems, work in groups, and communicate their understanding of mathematical concepts. The information gathered from the telephone conversations is included to support the survey data about instructional practices.

The Statistical Package for Social Sciences computer program was used for the data analysis. First, the mean and standard deviation were calculated for nineteen of the twenty survey items. Question 20 required a narrative response and is reported based on identified curriculums used for instruction.

Second, descriptive statistics were generated (items 12-17) for the group of teachers who scored at the 100% level and for the group that did not score at the 100% level. The results of the analysis are reported in the next chapter.
CHAPTER IV

RESULTS

Study Sample

The study sample (N=49) included grade 4 teachers from nineteen of the twenty-two schools in Rutland County Vermont. The responses from 37 teachers were combined to provide aggregate data to be analyzed. Twelve of the 18 teachers who agreed to follow-up interviews were reached by telephone and answered the follow-up questions. Two teachers returned the survey even though they did not currently teach mathematics (these were discarded).

The data were analyzed to determine a relationship between the level of teacher involvement in the mathematics portfolio assessment process and particular instructional practices used by the teachers. The study was designed to explore the relationship between the use of problem solving and mathematical communication in classrooms to teacher scoring of 100% of student portfolios. Classroom practices of teachers who did score 100% were compared to classroom practices of those who did not score at 100%.

Demographic information included gender, total grade 4 students, size of mathematics classes, teaching experience and professional development activities. Teachers were asked to provide the number of years of teaching experience and the number of years of teaching mathematics. 37 teachers responded to the survey, 3 men and 34 women. All three men agreed to participate in the follow-up telephone interview, one
was reached. The number of years teaching ranged from one to thirty-six. The mean number of years teaching was 16 (SD=11.21). The number of years teaching Grade 4 mathematics ranged from one to thirty-five. The mean number of years teaching mathematics at grade 4 was 9 (SD=8.59). Some teachers reported a change in teaching assignment to accommodate the need at their individual school.

The schools included in the sample had Grade 4 classes that ranged in size from 5 students per grade level to 225 students per grade level. Many Vermont schools are small, but the mean number of Grade 4 students in a school was 61 (SD=62.02). The average class size was 17 students (SD= 5.39). See Table 3.

Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range of responses</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years teaching</td>
<td>1-36</td>
<td>16</td>
<td>11.21</td>
</tr>
<tr>
<td>Years teaching math</td>
<td>1-35</td>
<td>9</td>
<td>8.59</td>
</tr>
<tr>
<td>Total grade 4 students</td>
<td>5-225</td>
<td>61</td>
<td>62.02</td>
</tr>
<tr>
<td>Class size</td>
<td>5-25</td>
<td>17</td>
<td>5.39</td>
</tr>
</tbody>
</table>

Data sorted by gender or years of experience did not explain the findings since teachers reported along curricula lines. The school-wide adoption of specific mathematics curriculum might be a factor. In many instances the number of years of teaching grade 4 mathematics was significantly different from the number of years of teaching. Teaching
assignments were changed to reflect local need.

Summary of Portfolio Involvement

All teachers (n=37) with one exception participated in professional development training for mathematics instruction. They all attended portfolio network meetings to practice scoring student portfolio pieces. The mean number of network meetings attended was 4 (SD=0.35). From the survey respondents 22 teachers indicated that they had attended more than five network meetings in the past five years. 29 teachers reported attending calibration sessions. Teachers attended fewer calibration sessions, and seven teachers never calibrated. The survey results showed a mean attendance of 2 (SD=1.6) times to calibration sessions.

The teachers were asked to check the reasons for their participation in the portfolio process. Fifty percent of the teachers indicated that it was voluntary. 31 respondents checked the Department of Education requirement for scoring 20% of student portfolios and 16 teachers checked administrative directive as the reason for participation. Some respondents selected more than one reason for their participation in the portfolio process.

The 20% sample of mathematics portfolios was submitted to the Department of Education in 1996 & 1998. The results of students’ performance from the state sample (n=1,327) were reported by sections from the rubric used to score student work (see Appendix A). Student responses to the complex problems are scored for approach and reasoning, connections, accuracy of solution, mathematical language, mathematical representation and documentation. The Vermont Department of Education published

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student results in each of the sections of the rubric as detailed in Table 4.

Table 4

State Results for Grade 4 Portfolios

<table>
<thead>
<tr>
<th>Scoring Rubric</th>
<th>1996</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach &amp; Reasoning</td>
<td>81%</td>
<td>91%</td>
</tr>
<tr>
<td>Connections</td>
<td>0%</td>
<td>3%</td>
</tr>
<tr>
<td>Accuracy of Solution</td>
<td>N/A</td>
<td>87%</td>
</tr>
<tr>
<td>Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematical Language</td>
<td>5%</td>
<td>9%</td>
</tr>
<tr>
<td>Representation</td>
<td>23%</td>
<td>36%</td>
</tr>
<tr>
<td>Documentation</td>
<td>85%</td>
<td>78%</td>
</tr>
</tbody>
</table>

Note: Percent reflects the students who scored 3 or higher in the category. Rubric was adjusted in 1996 (Vermont Department of Education, 2000).

The data were sorted for the frequency of teachers scoring 100% of student portfolios. The percent of teachers involved at the 100% level increased each year that was surveyed. During the 1997-1998 school year 44.4% scored at the 100% level; 1998-1999 52.8% of the teachers reported scoring at the 100% level; 1999-2000 58.3% of the teachers scored at the 100% level. The percent of teachers involved at the 100% level of scoring showed a significant increase during the three-year period included in the study sample.
Analysis of Data in Relation to Research Hypotheses

Level of Portfolio Scoring by Teachers

The data from the surveys were sorted by teachers who scored 100% of student portfolios \((n=21)\) and by those who did not score 100% \((n=9)\). The level of scoring was compared to the time teachers reported they spent teaching skills, concepts, and problem solving. Time given to the specific focus of instruction was reported on a 5-point Likert Scale with choices never (1), rarely (2), sometimes (3), often (4), always (5).

The mean score for teaching skills was 4.52 (SD=0.60) for 100% scoring and 3.89 (SD=0.78) for not scoring 100%. The mean score for teaching concepts was 4.43 (SD=0.60) for 100% scoring and 4.22 (SD=0.67) for not scoring 100%. The mean score for teaching problem solving was 4.14 (SD=0.57) for 100% scoring and 3.89 (SD=0.33) for not scoring 100%. The differences between the groups were not statistically significant.

Focus of Instruction

The survey data were sorted for frequency that skills, concepts or problem solving were the focus of instruction. Teachers selected a response from a 5-point Likert scale: never, rarely, sometimes, often, always. Teachers responded that concepts, skills, or problems solving were the focus of instruction “sometimes”, “often” or “always.” No teacher responded to the choices “never,” or “rarely.”
Table 5

Instructional Focus

<table>
<thead>
<tr>
<th>Type of Instructional Focus</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts</td>
<td>5.6%</td>
<td>50%</td>
<td>41.7%</td>
</tr>
<tr>
<td>Skills</td>
<td>13.6%</td>
<td>38.9%</td>
<td>44.4%</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>11.1%</td>
<td>69.4%</td>
<td>16.7%</td>
</tr>
</tbody>
</table>

Skills were checked by 44.4% of respondents as “always.” Concepts were checked as the focus of instruction “always” by 41.7% of respondents. Only 16.7% selected “always” to focus on problem solving. Skills were reported to be the focus of instruction most often, even though there was significant attention given to concepts.

The instructional practices used by the 100% scoring group were compared to the group that did not score at the 100% level. The data were sorted from the Likert scale responses for the 1999-2000 school year. The mean scores and standard deviations for each instructional practice are reported in Table 6. None of the differences in time spent on instructional practices between the groups was statistically significant.
### Table 6

**Time Spent on Instructional Strategies and Levels of Scoring in 1999-2000**

<table>
<thead>
<tr>
<th>Instructional Strategy</th>
<th>100% scoring (n=21)</th>
<th>Not 100% scoring (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Write Solutions</td>
<td>3.95</td>
<td>.67</td>
</tr>
<tr>
<td>Groups or Pairs</td>
<td>4.05</td>
<td>.59</td>
</tr>
<tr>
<td>Explain to Class</td>
<td>3.71</td>
<td>.72</td>
</tr>
<tr>
<td>Instruct in Problem Solving</td>
<td>3.95</td>
<td>.38</td>
</tr>
<tr>
<td>Instruct Portfolio Problems</td>
<td>3.95</td>
<td>.38</td>
</tr>
<tr>
<td>Evaluate with Rubric</td>
<td>4.19</td>
<td>.60</td>
</tr>
</tbody>
</table>

Survey items 12-17 were designed to measure teacher use of specific instructional practices in their mathematics classrooms. The mean scores ranged from 3.71 to 4.19 for the group of teachers who scored 100% of student portfolios. The mean scores ranged from 3.22 to 4.00 for the teachers who did not score 100% of student portfolios.

**Mathematics Curricula**

Next the data were sorted by curriculum, standards-based or traditional and compared to the teacher reported use of the instructional strategies in survey questions 12-17. It is interesting to note that survey question 14 about the frequency that students explained solutions to the class was reported at a mean rate of 4.22 (SD=0.83), the highest mean for questions 12-17 from the teachers who used traditional curricula. The mean scores between groups did not show a significant difference.
Table 7

Curriculum Use and Instructional Practice

<table>
<thead>
<tr>
<th>Instructional Strategy</th>
<th>Traditional (n=9)</th>
<th>Standards-Based (n=26)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Write Solutions</td>
<td>3.89</td>
<td>.93</td>
</tr>
<tr>
<td>Groups or Pairs</td>
<td>4.00</td>
<td>.50</td>
</tr>
<tr>
<td>Explain to Class</td>
<td>4.22</td>
<td>.83</td>
</tr>
<tr>
<td>Instruct in Problem Solving</td>
<td>4.11</td>
<td>.33</td>
</tr>
<tr>
<td>Instruct Portfolio Problems</td>
<td>3.89</td>
<td>.60</td>
</tr>
<tr>
<td>Evaluate with Rubric</td>
<td>3.89</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Frequency of Use of Instructional Practices

Teachers were asked to respond using a 5-point Likert Scale (never, rarely, sometimes, often, or always) to indicate the frequency that specific instructional practices were included in their classrooms. The responses to the questions about instructional practice were collected for three school years: 1997-1998, 1998-1999, and 1999-2000. The percentage of teachers responding to the question as “often,” or “always” using the instructional strategies is included in the following table.
Table 8

Percent of Teachers who “Often” or “Always” Use the Instructional Strategies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Write Solutions</td>
<td>55.6%</td>
<td>61.1%</td>
<td>77.8%</td>
</tr>
<tr>
<td>Groups or Pairs</td>
<td>52.8%</td>
<td>61.1%</td>
<td>77.8%</td>
</tr>
<tr>
<td>Explain to Class</td>
<td>38.9%</td>
<td>47.2%</td>
<td>66.7%</td>
</tr>
<tr>
<td>Instruct in Problem Solving</td>
<td>47.3%</td>
<td>61.1%</td>
<td>86.1%</td>
</tr>
<tr>
<td>Instruct Portfolio Problems</td>
<td>50%</td>
<td>58.4%</td>
<td>80.6%</td>
</tr>
<tr>
<td>Evaluate with Rubric</td>
<td>52.8%</td>
<td>61.1%</td>
<td>66.6%</td>
</tr>
</tbody>
</table>

The percentage of teachers who included the specific strategies necessary for students to become complex problem solvers and mathematical communicators increased each school year in each category. Portfolio problems were used more often as was instruction in problem solving. Use of the evaluation rubric increased, but teachers noted that it was most often used for portfolio problems that were scored for submission as required by the Vermont Department of Education.

Descriptions of Typical Mathematics Lessons: Survey and Telephone Interview Data

The respondents were asked to describe a typical mathematics lesson. All but two teachers provided a description. Each school in the survey used the same curriculum across the grades, some were standards-based and some were traditional. The surveys were grouped by mathematics curriculum and the lesson descriptions were reviewed for similarities. The descriptive information about typical lessons reflected the components of
lessons specific to the program used in the classroom. The teachers who responded to the telephone survey questions supplied specific information about supplemental materials.

Mathland and Everyday Mathematics were the most widely used programs for mathematics instruction based on the survey data. Both programs are standards-based and align with the NCTM and Vermont standards (24 respondents) (see Table 9). Two other standards-based programs were reported in use: Opening Your Eyes to Math and Investigations in Mathematics for Grade 4. Traditional mathematics programs were used in three locations (10 respondents): Heath, Houghton Mifflin/Saxon, and Addison Wesley/Math Plus (Vermont Institute for Science, Mathematics, and Technology, 1996).

(Note: The Vermont Institute for Science, Mathematics, and Technology reviewed mathematics curriculum for alignment with the Vermont Framework of Standards. The resulting report sorted curricula into two categories: standards-based and traditional. The report findings provide the basis for curriculum categorization in this study.

The specific curricula identified by participants in the study are listed in Table 9. Survey question 19 asked teachers to identify the mathematics curriculum they used in their classrooms.
Table 9

Curriculums in Use (n=7)

<table>
<thead>
<tr>
<th>Curriculum</th>
<th>Standards-Based</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathland</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Everyday Math</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Addison Wesley</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Opening Eyes to Math</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Heath</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Investigations for Grade 4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Houghton Mifflin/Saxon</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Note: The number reflects teachers who use the programs.

One teacher reported using the Heath mathematics program that is skill-based. The “typical” lesson described by that teacher began with the introduction of a concept followed by problem solving activities. The text was used at the end of the lesson to practice computation. During the follow-up telephone interview, the teacher explained that the school had changed to the Mathland program for the 2000-2001 school year. Supplemental materials included Marilyn Burns’ creative problem solving materials, hands-on explorations and mathematics games. Manipulatives were often used. The classroom instruction was standards-based and portfolio problems were a regular part of the classroom instruction despite the adoptions, up until now, of a skill-based traditional curriculum.

Three teachers reported using the Saxon series published by Houghton Mifflin, a skill-based traditional program. The written descriptions from each teacher were similar.
A skill was introduced on a daily basis and students practiced that skill. The teacher moved around the room as students practiced the skill. Homework was assigned to continue the practice. One day each week was set aside for portfolio work. None of the respondents included names or telephone numbers in their survey responses. There were no telephone interviews.

The respondents that used the Addison Wesley series described skill driven instruction. Students completed seatwork while the teacher moved about the room. Homework was assigned to practice the skill introduced during the lesson. One user indicated that whole group problem solving happened about once a week, but it was not a regularly scheduled activity. No follow-up telephone interviews were conducted since no telephone numbers were provided in the survey responses.

Two teachers reported using standards-based programs that focus on problem solving activities: Opening Your Eyes to Math and Investigations for Grade 4. Both teachers wrote that students used mathematics manipulatives to explore new concepts and that problem solving was a daily activity. Portfolio problems were often a part of instruction. Neither teacher could be reached for the telephone interviews, even though both expressed a willingness to participate.

The standards-based Mathland curriculum had 10 teacher users. One teacher indicated on the survey that supplemental materials were included as a part of regular instruction. The program included specific units and teachers selected which units they taught. Problem solving was the focus of most instruction. Students were given “tune-ups” at the beginning of a lesson. The “tune-up” was a time for students to explain a concept, practice a skill or convince the teacher about their solutions to a specific
problem. Next students worked in small groups or pairs to solve a problem. The solutions were reported to the whole class. If students were investigating or making predictions, a chart or graph of their results would be shared with the class. Some teachers had students write in mathematics journals about their learning or findings for the day. Portfolio problems and problem solving activities were listed as supplemental materials. It was unclear in the survey responses how teachers selected the units used for instruction.

Eight of the ten Mathland users were willing to participate in the follow-up telephone interviews; six teachers were contacted. They explained opportunities provided for students in their classrooms to speak and write about their understanding of mathematical concepts and solutions to complex problems. The activities described by the teachers reflected many interactions between the students. The students explained their thinking or wrote about their solutions. The teachers used an overhead projector to present new concepts and group discussions followed the presentation. Two teachers reported an hour of instructional time was devoted to mathematics. Students made charts and graphs to explain solutions to problems, and manipulatives were part of every class. They indicated that students had many opportunities for discussion of mathematical ideas and solutions; students were working together to construct knowledge (Cobb, Wood, & Yackel, 1990).

Each teacher using Mathland who participated in the follow-up telephone interviews reported using supplemental materials. Three teachers supplemented their curriculum with computation materials. The other three added portfolio problems and problem solving materials from the Marilyn Burns book from Creative Publications. The teachers indicated, “Additional materials were necessary for students to have a
comprehensive learning experience.” The portfolio scores were reviewed by two of the teachers. One teacher indicated that the scores from the New Standards Reference Exam required by the Department of Education had a greater influence on instruction than the portfolio process. The same teacher used and supported the portfolio process and believed the problems blended with the curriculum.

Fourteen teachers reported using the Everyday Math curriculum. The lessons described by the teachers who used Everyday Math were similar to the description of lessons in the Mathland classrooms. Each day began with a math message followed by a warm-up activity. The message was a practical application and the warm-up introduced the new concept. The introduction to the lesson included vocabulary and review of previously taught concepts that were related to the lesson. There was whole group discussion about the new concept. The students then worked in small groups on the problem in the lesson. Students used math journals to record their solutions. Math Boxes (a component of the program) were assigned to students to review and reinforce skills and concepts. Homework was assigned from the study links materials in the program or students were given math computation packets. Students were assigned a problem each week and their solutions could be included in their portfolios.

Five of the teachers who used Everyday Math were reached for the telephone interviews; two additional teachers who agreed to the interview could not be reached. The teachers reported frequent use of manipulatives to teach mathematical concepts. Students worked in small groups or in pairs to practice. Problem solving or portfolio problems were integrated into daily instruction. Students assessed their own work and provided feedback to each other. Using mathematical language and explaining the
connection of the solutions to the real world were part of the classroom practice activities. There were efforts to make students capable of communicating their understanding of the mathematics (Lappan & Briars, 1995).

Computation packets were identified in the telephone conversations by four of the teachers using *Everyday Math* as the supplemental materials used. One teacher used supplemental problem solving assignments in addition to computation and one teacher only supplemented with problem solving, often using portfolio problems. The teachers indicated in the telephone conversations that problem solving activities prepared students for the portfolio process.

Three of the teachers using *Everyday Math* reported that they reviewed the portfolio scores. They indicated specific work aimed at improving student use of mathematics language was included in their instruction as a result of the review. The teachers reviewed the scores from the New Standards Reference Exams and the combined data were used in the Action Plan (Vermont Department of Education, 1999) developed for the school. Specifically, the school Action Plans had a goal for improving student scores on mathematics portfolios. One teacher reported that the portfolio scores were not discussed, but the scores from the New Standards Reference Exams were reviewed very carefully. The data from the state exam were used to develop the school’s Action Plan. One teacher did not review any test data.

**Summary**

The survey data were analyzed to test the original hypotheses. No significant
differences were found in the frequency with which particular instructional practices were used between the group of teachers who scored 100% of student portfolios and the group that did not score 100% of student portfolios.

Further analysis of the data from the survey responses revealed that there was an increase in the use of instructional strategies that were included in the survey. The instructional practices included in the survey would support complex problem solving and mathematical communication, practices one would expect to be most apparent in a standards-based curriculum under the Vermont definition. Teachers' participation in the portfolio process increased for each school year included in the survey. Teachers indicated a willingness to participate in the portfolio training sessions and used the instructional strategies that supported portfolio problems to a greater degree each school year.

The teachers reported in the telephone interviews that they used the portfolio assessment process in conjunction with their instruction in problem solving. The teachers who participated in the telephone interviews indicated that they used computation practice as a supplement to their curriculum. Many of the teachers interviewed by telephone indicated that they did not review the portfolio scores that were returned to the schools from the Vermont Department of Education, but several indicated that they did review the scores from the state mandated New Standards Reference Exam.
CHAPTER V

DISCUSSION OF FINDINGS AND CONCLUSIONS

Overview of the Research Project

The ten years of experience by teachers with the mathematics portfolio process led to questions about the need for teachers to participate in the scoring process of the portfolios at the 100% level. Instructional practices used by teachers that prepared students to participate in the portfolio process were not known. At the same period of time Vermont added an assessment of student performance in mathematics that required students to be complex problem solvers (Vermont Department of Education, 1997). The addition of the New Standards Reference Exam to the comprehensive assessment system for all Vermont students created an environment where teachers had to prepare students to perform successfully on both assessment instruments.

The study was structured to examine a relationship between mathematics instruction in problem solving and communication, indicators of reform-based teaching, and the level of teacher involvement in the portfolio assessment process. Specifically, data from the study were analyzed to answer the research question: “Is the way in which grade 4 mathematics is taught among Vermont teachers related to their level of involvement in the portfolio assessment process?”

The study sample (n=49) included grade 4 teachers in Rutland County, Vermont.
All 22 schools that have grade 4 students enrolled were invited to participate, nineteen schools responded. The survey instrument of 20 questions included one that required a brief narrative. The questions focussed on instructional practices in mathematics and the level of teacher participation in the portfolio process. Demographic data, information about attendance to training and calibration sessions plus the reason for teacher participation in the process were requested in the survey questions.

Findings

The study results were analyzed to test the two hypotheses regarding the level of teacher participation in the portfolio process and their instructional practices. The first hypothesis that teachers who score 100% of student portfolios will tend to use mathematics instruction that maintains elements of problem solving and mathematical communication was examined. The second hypothesis that teachers who did not score or only scored 20% of student mathematics portfolios will not tend to use mathematics instruction that maintains elements of problem solving and communication was examined. There was no significant difference between the groups. However, the data from the teachers suggested that an increase over time in the use of instructional strategies that support problem solving and mathematical communication did occur.

Teachers were asked to report their level of scoring mathematics portfolios for the past three school years. The results indicated that the number of teachers participating at the 100% level increased each year. The number of teachers scoring at 100% changed from 16 in the first year to 19 in the second year and 21 in the third year. The results suggest that the increase in participation was a decision made by the teachers.
The survey results seem to indicate that students have the practice opportunities needed to become complex problem solvers and mathematical communicators (see Table 8). Working in small groups, solving complex problems and reporting solutions are instructional strategies that increased in use for each school year that was included. The teachers who reported using a standards-based curriculum described lessons that included opportunities for students to solve problems and communicate solutions. In schools where a more traditional program of instruction was used, students were given some time to participate in problem solving activities including portfolio problems as a part of regular instruction. In the telephone interviews many teachers did report using materials to supplement instruction that were skill-based, often practice in computation. The supplemental work was not included during the regular mathematics instructional time. Teachers seemed unwilling to completely sacrifice skill practice for problem solving.

The results from the New Standards Reference Exam that is a spring assessment for Grade 4 students in mathematics support the findings of this study. During the three-year period, scores in concepts and problem solving increased steadily in Rutland County. Students were most successful in the skill portion of the assessment, but also improved in conceptual understanding and to a lesser degree in problem solving.
Table 10

Rutland County Results for the New Standards Reference Exam

<table>
<thead>
<tr>
<th>Area of Assessment</th>
<th>Assessment Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts</td>
<td>25%</td>
</tr>
<tr>
<td>Skills</td>
<td>63%</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>19%</td>
</tr>
</tbody>
</table>

Note: Percent of Grade 4 students in the highest two performance levels: Achieving the standard or achieving the standard with honors (Vermont Department of Education, 2000).

The increase in the number of students who met or exceeded the standard in concepts has increased each year of the testing. The same is true for skills and problem solving. The emphasis on skills as a supplement to regular instruction reported by the teachers is supported in the test results. The increase in the scores in concepts and problem solving coincides with teachers self-reporting of increased class time given for instructional strategies identified in the survey. Students were given more time to work together, communicate their solutions orally and in writing plus they solved more portfolio problems. The addition of the instructional practices identified in the survey suggested that teachers are following the recommendations from the NCTM in the curriculum standards (1989) and the Vermont mathematics standards from the Framework (1996).

The data were sorted to determine a possible relationship between the level of scoring and the focus of instruction. Level of scoring was divided into two categories, 100% or not 100%. The survey results did not reveal a significant difference between the
level of scoring and the focus of instruction. Next the data were sorted by curriculum, standards-based or not standards-based. The curriculum data were compared to level of scoring with no significant difference indicated.

Reviewing the data by school year and comparing instructional practices did reveal an increase in the use of instructional practices that supported problem solving and mathematical communication. Teachers reported an increase in the use of the instructional strategies included in the survey. More teachers scored portfolios at the 100% level each year and their participation at that level was largely by choice. The data indicate a purposeful effort by the teachers to insure that students made continuous progress and improved their scores on both the portfolio problems and the New Standards Reference Exam.

Previous research studies that examined the portfolio process focussed on the need for teachers to learn how to teach problem solving (Koretz, et. al., 1993). Teachers in the current study did indicate that they were clear about the instructional strategies they needed to use. The portfolio process is firmly in place and part of regular instruction. The results compiled from the survey seem to suggest that schools in Rutland County have become learning organizations (Senge, 1990). The teachers have organized their classrooms to include instructional strategies so students can participate successfully in the portfolio process and the state assessment.

The study conducted by Carroll (1997) collected data related to student performance on the Illinois State Mathematics Test. Students who were taught using a standards-based program that offered frequent opportunities for small group work and communication showed a significant increase in their performance on the state assessment.
that was structured in a traditional format. Mathematics instruction did not need to focus on algorithmic practice for students to learn skills. Students with rich understanding of mathematics concepts that they used to solve problems were very successful on the standardized, traditional, more skill driven assessment. The teachers in Rutland County are paving the way for students to become skilled problem solvers and proficient communicators in mathematics through the addition of specific instructional strategies in their classrooms. However, the teachers now supplement their instructional practice with computational packets for students.

It was difficult to determine the catalyst for the shift in instructional practices. The portfolio process has been in place for ten years, long enough for a systemic change process to be sustained (Fullan, 1993). Teachers reported using the portfolio process as volunteers and the number of volunteers increased each school year included in the survey. However, the high stakes testing that was instituted in 1997 could have played a significant role in the results gathered from the survey. Sorting the two, high stakes testing and the portfolio process for impact on instructional practice would be a topic for further research.

The goal set by the Vermont Department of Education, the Legislature and the Governor of Vermont was for students to show continuous improvement (Vermont Department of Education, 1999). Laws were created and standards for student performance that are tested by a comprehensive assessment system were set (Vermont Department of Education, 1997). The grade 4 students in Rutland County did show improvement in the three years included in this study (Schmoker, 1996). Teachers have become more involved in the portfolio process. They have changed their instruction. The
schools and more important, the teachers have data to show that their instruction is leading to academic growth of their students. The results from a range of assessment tools are now available for teachers to use as they plan for instruction, although many have not yet directly used the portfolio scores. The survey results did indicate that there were increases in specific instructional practices in mathematics classrooms, and student performance has improved. This study points out that an alignment of standards, teaching practices, and assessments is possible, and in Rutland County, successful.

Limitations of Study and Recommendations for Further Research

This study was conducted in Rutland County Vermont and all schools with grade 4 students were invited to participate. The participants in the study shared information and included descriptions of their instructional practice. Even taking into consideration the tendency for teachers to over-report their actions, the results indicated a gradual shift in instructional practice (Thompson, 1992). The size of the schools in the county may limit the use of the study results beyond Rutland County. Many of the schools in the sample had a very small number of students in grade 4. The enrollment of grade 4 students varied from 5 students in one school to 225 students in another school. Rutland County appeared to be similar to other counties in the state, but the results may not be generalizable to all counties in the state. The number of schools in the county and the size of the grade 4 classes would need to be reviewed to make comparisons to other counties.

Mathematics teachers in the county piloted the survey instrument, but it has not been tested over time for reliability. The study could be duplicated in other counties to see if similar trends are occurring. Additional reliability testing could be done with a larger
sample that could validate or contextualize the current data. Broadening the study to include more teachers might offer results that could be used by the Vermont Department of Education as it plans for future data collection.

Teachers reported using the portfolio assessment process as a regular part of their mathematics programs and the number of teachers scoring at the 100% has increased. All data were self-reported and several survey questions were answered using a 5-point Likert scale. The survey questions focused on particular instructional practices, but other indicators of implementation of reform-based teaching could be reviewed. The survey data reflect standards-based teaching in Vermont and may not be the case in other states, depending on their standards.

The aim of this study was to discover a relationship between mathematics instruction and portfolio scoring. The discovery that teachers are including more learning opportunities for students to become complex problem solvers and mathematical communicators was encouraging. More students are meeting or exceeding the standards for performance set by both the Vermont Department of Education and the National Council of Teachers of Mathematics. There seemed to be a significant shift in the focus of instruction from “teacher-directed” to “teacher-facilitated” based on the reported inclusion of group work and student reported solutions to complex problems. The results of the study, given the identified limitations, painted a hopeful picture for the success of the youth from Rutland County.
BIBLIOGRAPHY


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Thayer, Y. (2000). *Virginia’s standards make all students stars: Standards, testing, accountability, reporting-these are the components of Virginia’s new Standards of Learning.* *Educational Leadership, 57*(5), 70-72.


Vermont Department of Education. (1998) Teacher surveys: Grades 1-3, grade 4, grade 6 science, grade 8, high school science, high school mathematics, high school English/language arts. Montpelier, Vermont.


Vermont Elementary and Middle Level Mathematics Portfolio Scoring Guide

This scoring guide was developed by the Vermont Department of Education, in collaboration with the Vermont Institute for Science, Math and Technology.

Raising Scores in Problem Solving

Preparing Students to Meet the Standards

102
## Approach and Reasoning

### Approach
- Approach wouldn't work or no approach evident

### Reasoning
- Approach worked or would work for solving the problem, and reasoning, if evident, is not flawed (Note: Use of a formula is an approach that worked or would work)

- Approach worked, and at least one of the following 3 additional aspects of good problem solving is evident:
  - Justifying the application of a known formula or rule used to solve all or part of the problem
  - Making a formula or rule used to solve all or part of the problem
  - Describing verification of her/his solution

## Connections

### Response
- Made a mathematically relevant observation about her/his solution or identified an underlying mathematical concept or pattern in her/his solution or solved the problem and then recreated the problem and found a new solution or solved the problem and then used a different mathematical process to solve the same problem

#### Level 1
- Related this problem to a similar problem or a real world phenomenon by expressing the mathematical relationship(s)
- Analyzed the relationship among elements in her/his solution or among similar or different mathematical topics in her/his solution or tested and accepted and/or rejected an hypothesis or conjecture about her/his solution or identified a formula or rule, while solving the problem, that worked or would work in solving all or part of that problem

#### Level 2
- Solved the problem, discovered a general rule about the solution, and demonstrated understanding of the generalization either through explanation of the derivation, or through application to more than one other case or solved the problem, and then extended her/his solution to a more complicated situation or evaluated the reasonableness or significance of her/his solution

### Solution
- The answer is correct, and the work in the solution supports the answer or the solution is correct for only part of the problem, and there is work to support those correct part(s)
- The solution contains mathematical errors which lead to an incomplete or incorrect answer or the answer is correct, and the work in the solution supports the answer

#### Level 1
- No work is present or no part of the solution is correct or some work is present, but the work doesn’t support the answer given

#### Level 2
- The solution is correct for only part of the problem, and there is work to support those correct part(s)
- The solution contains mathematical errors which lead to an incomplete or incorrect answer

#### Level 3
- The answer is correct, and the work in the solution supports the answer

---

1 Would: An approach that would work for solving the problem addresses all aspects of the mathematical situation presented in the task. An approach that would work may contain mathematical errors, an incorrect solution, or may be incomplete.

2 Part of the Problem: Within a problem, there may be several mathematical components that need to be addressed, or there may be multi-parts. If not all of the mathematical components of the problem are addressed, or not all of the parts of the problem are addressed, then the student only found an approach to solve part of the problem.

3 Solution: All of the work that was done to solve the problem, including the answer.

4 Recreated: The student substituted different numbers in the same problem and found another solution, or used the same procedure in a different circumstance

5 General Rule: A rule that can be used no matter what the numbers in the problem are, either expressed in algebraic notation or in words.
Mathematical Language: Terms/vocabulary and symbolic notation

<p>| START HERE |</p>
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<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
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<tbody>
<tr>
<td>• Is absent or contains significant flaws in accuracy</td>
<td>• Is relevant, but may contain minor flaws and is the sparse use of the language of... - Number sense and numeration, number relationships, number systems and number theory (including fractions and decimals) - Geometry and measurement, or - Statistics and probability, or - Patterns, functions, and algebra or - Demonstrates understanding of non-computational language presented in the task (Note: Use of a single non-computational term rarely merits a level 2)</td>
<td>• Is relevant and contains no significant flaws and demonstrates understanding through... - Consistent use of non-computational language beyond that presented in the task, including the language of... - Number sense and numeration, number relationships, number systems and number theory (including fractions and decimals) - Geometry and measurement, or - Statistics and probability, or - Patterns, functions, and algebra or - Use of algebraic or other notation(s)?</td>
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Mathematical Representation: Graphs, plots, charts, tables, models and diagrams

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<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
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<tbody>
<tr>
<td>• Didn't attempt to make any mathematical representations to solve or communicate an aspect of her/his solution, regardless of the correctness of the solution or • Made only inappropriate mathematical representations to solve or communicate an aspect of her/his solution regardless of the correctness of the solution</td>
<td>• Attempted to make an appropriate mathematical representation to solve or communicate an aspect of her/his solution, regardless of the correctness of the solution, but the representation lacks labels and/or accuracy with regard to the student's solution. (Note: Completion of a teacher structured representation cannot earn above a level 2)</td>
<td>• Made an appropriate and accurate mathematical representation to solve or communicate an aspect of her/his solution, regardless of the correctness of the solution. See glossary for requirements. (Note: The student's text may supply the necessary labeling).</td>
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Documentation

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<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
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<tbody>
<tr>
<td>• The documentation of the student's correct or incorrect solution contains little or no evidence of how the problem was solved or the reasoning used</td>
<td>• The documentation of the student's correct or incorrect solution contains some clear parts, but there are gaps in how the student solved the problem or the reasoning used</td>
<td>• The documentation of the student's correct or incorrect solution clearly shows how the problem was solved, and the reasoning used. This may be evident by some of the following... - Results of any necessary computation are present - Answers are highlighted - Presentation is in logical order - Representations are linked to text - All parts are connected and labeled</td>
</tr>
</tbody>
</table>

1. Measurements: Attributes of length, capacity, weight, mass, area, volume, time, temperature, and angle
2. Notation: Includes the use of algebraic equations and formulas (with all variables defined), and/or other notations (i.e., summation and exponential notations)
3. Accurate: Mathematical representations that are technically correct and executed properly, including labels. See glossary.
April 18, 2000

Dear Colleague:

I am a doctoral student in the Ph.D. program in education at the University of New Hampshire and I am requesting your assistance so I can complete my dissertation study. I hope to discover a relationship between mathematics instruction and the level of participation in the portfolio assessment process. Would you personally inform your grade 4 teachers and request their participation?

The survey, a letter to the teacher and a self-addressed stamped envelope are included with this letter. There is one packet for each grade 4 teacher in your building. The teachers will need about fifteen minutes to complete the survey. Every response will help with my research. I am very interested in instruction and I assure you that neither your school, nor any of your staff members will be identified.

If you have questions or would like to discuss this project, please give me a call at school (802 438-2288), or at home (802 775-7163). If you would like a copy of the survey results, please call me, or send a written request and I will send the results to you. I sincerely appreciate any assistance you can give me on this project.

Sincerely,

Carol Fritz
Principal
April 19, 2000

Dear Educator:

I want to begin by thanking you for agreeing to assist me with my research. Time is a precious commodity and I appreciate your giving me the time it will take to complete the survey. Your help will be of great assistance. I am a doctoral student in a Ph.D. in education program at the University of New Hampshire and the attached survey is part of my dissertation research. I am a Vermont principal and very interested in exploring mathematics instruction at grade 4 and the level of involvement of teachers in the portfolio assessment process.

I contacted the principal of your school by telephone and sent a follow-up letter asking for your assistance. Please complete the survey and return it to me in the self-addressed stamped envelope. I will add your answers to those of other grade 4 teachers in Rutland County. Your responses will be kept strictly confidential. Neither you nor your school will be identified. I sincerely appreciate your willingness to participate in my project.

If you have any questions or concerns, please contact me at school (802 438-2288), or at my home (802 775-7163). Your principal could also provide additional information. If you would like a copy of the survey results, just add your name and address at the end of the survey document. I will gladly mail the information to you when it is compiled. Again, my thanks for your time.

Sincerely,

Carol Fritz
Principal
The Level of Teacher Involvement
In the Vermont Mathematics Portfolio Assessment Process
And Instructional Practices in
Grade 4 Classrooms

Please respond to the survey questions. Your responses will be held in strictest confidence. Your participation in the research is greatly appreciated.

DEMOGRAPHICS

1. Gender: __Male   ____Female

2. Counting this year, how many years have you taught school? ____

3. Counting this year, how many years have you taught grade 4 mathematics? ____

4. How many grade 4 students are enrolled in your school? ____

5. What is the average number of students in your mathematics class this year? ____

PORTFOLIO TRAINING

6. How many portfolio network meetings have you attended in the last 5 years?

   ____0
   ____1
   ____2
   ____3
   ____4
   ____5 or higher

7. How many annual calibration sessions have you attended in the last 5 years?

   ____0
   ____1
   ____2
   ____3
   ____4
   ____5 or higher
8. What percent of your students’ portfolios did you score for each year? Please check the appropriate box for each year that applies.

<table>
<thead>
<tr>
<th>Year</th>
<th>0%</th>
<th>20%</th>
<th>21-99%</th>
<th>100%</th>
<th>N/A</th>
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<tr>
<td>State sample</td>
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<tr>
<td>School scoring</td>
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<tr>
<td>Not sure</td>
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98-99
99-00

9. What best describes your participation in the portfolio process? Please check all that apply.

- No involvement
- Directed by the administration
- Voluntary use of process
- Compliance with state requirements

INSTRUCTIONAL PRACTICE

10. Does your school’s Action Plan include a performance goal for Grade 4 mathematics?

- Yes
- No
- Not sure

If yes, what is the goal?

11. Have you participated in professional development training for mathematics instruction?

- Yes
- No (If no, go to next question.)

Please check all that apply.

- Training provided at your school.
- Workshop in mathematics instruction
- Conference on instructional practices
- College course on instructional practice
- Other (Please explain)
12. How often do your students write an explanation of their solutions when problem solving in mathematics?

<table>
<thead>
<tr>
<th>Year</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
<th>N/A</th>
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13. How often do your mathematics students work in small groups or pairs?

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<th>Year</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
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</table>

14. How often do your students explain their solutions to the class?

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<tr>
<th>Year</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
<th>N/A</th>
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15. How often is problem solving the focus of instruction?

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<th>Year</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
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<th>N/A</th>
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16. How often are portfolio problems included as a part of your classroom instruction?

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<th>Year</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
<th>N/A</th>
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17. How often do you use the scoring guide/rubric to evaluate student work?

<table>
<thead>
<tr>
<th>Year</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
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</table>
18. In your mathematics instruction how much emphasis do you place on each of the following areas?

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
<th>Not Sure</th>
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</thead>
<tbody>
<tr>
<td>Skills</td>
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<tr>
<td>Concepts</td>
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<tr>
<td>Problem Solving</td>
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</table>

19. What mathematics curriculum or program do you use for instruction?

Program name: ___________________________________________

20. Would you describe a typical mathematics lesson in your classroom?

Could I contact you for a brief interview? _____ Yes _____ No

If yes, please indicate your name and a phone number where you can be reached.

Name: ___________________________ Phone: (work) _______________
        (home)______________

Many thanks for taking the time to help me with my research!

Sincerely,
TELEPHONE SURVEY

VOLUNTEERS

Name: ________________________ Date: _____________

1. Are you following and using a standards-based curriculum?
   Program: Supplemental materials?

2. Describe your instructional practice in mathematics. If I walked into your classroom what would I see you doing?

3. Describe the learning opportunities the students have. What do they do?

4. When the portfolio scores are returned to your school, do you review the scores? Do you use the information to plan instruction in your classroom? How?
The Institutional Review Board for the Protection of Human Subjects in Research has reviewed the protocol for your project as Exempt as described in Federal Regulations 45 CFR 46, Subsection 46.101 (b) (2), category 2.

Approval is granted to conduct the project as described in your protocol. Changes in your protocol must be submitted to the IRB for review and approval prior to their implementation.

The protection of human subjects in your study is an ongoing process for which you hold primary responsibility. In receiving IRB approval for your protocol, you agree to conduct the project in accordance with the ethical principles and guidelines for the protection of human subjects in research, as described in the Belmont Report. The full text of the Belmont Report is available on the OSR information server at http://www.unh.edu/osr/compliance/belmont.html and by request from the Office of Sponsored Research.

There is no obligation for you to provide a report to the IRB upon project completion unless you experience any unusual or unanticipated results with regard to the participation of human subjects. Please report such events to this office promptly as they occur.

If you have questions or concerns about your project or this approval, please feel free to contact me directly at 862-2003. Please refer to the IRB # above in all correspondence related to this project. The IRB wishes you success with your research.

For the IRB,

Kara L. Eddy, MBA
Manager, Regulatory Compliance

cc: File
Judith Robb, Education - Morrill Hall