

EFFECTS OF INTEGRATING WRITING ACTIVITIES ON STUDENTS' ATTITUDES AND
ACHIEVEMENT IN PROBLEM SOLVING: AN ACTION RESEARCH STUDY

by

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A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Education
in the Department of Teaching and Learning Principles
in the College of Education
at the University of Central Florida
Orlando, Florida

Spring Term
2005

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ABSTRACT

This action research study investigated my practice of using writing activities in the mathematics classroom. The study was conducted to determine the effect of integrating writing with mathematics on students' achievement in, and attitudes towards problem solving, and the relationship between students' attitudes and their achievement in problem solving. The study was conducted over a six-week period. Students participated in daily problem solving activities. Data were collected using a problem solving themed writing rubric for evaluating student journal responses, anecdotal records, and using a pre- and posttest problem solving attitude inventory.

In this study, students demonstrated overall increased mathematical knowledge, strategic knowledge, and abilities to explain their procedures. In addition, all three data-collection instruments demonstrated students' positive attitudes toward problem solving. Moreover, evaluation of the data sources illustrated a relationship between students' performance and attitudes. The study suggested that writing about mathematics is beneficial to students' achievement and attitudes toward problem solving.

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CHAPTER ONE: INTRODUCTION

Rationale for the Study

Over the past twenty years, there has been a re-examination of the bonds among the 3Rs – reading, writing, and arithmetic (Bell & Bell, 1985). Research indicates that writing has important implications for the learning and teaching of mathematics (Bell & Bell, 1985; Miller & England, 1989; Silver, Kilpatrick, & Schlesinger, 1990; Meier & Rishel, 1998; Whitin & Whitin, 2000). According to their study, one benefit associated with writing assignments is, they provide an avenue for students to develop and present their own thoughts and perspectives on the mathematics they were studying (Miller & England, 1989). They concluded, “Writing about mathematics is a very empowering experience for students” (p. 310). By participating in writing activities, students are able to construct their own meaning and take control over their learning (Meier & Rishel, 1998). In addition, the objective of writing to learn a content area is to focus the student’s thinking toward a better understanding of the subject matter.

During my graduate work, I have adopted a constructivist philosophy of teaching. In contrast to the traditional classroom, I believe education should be student-centered, and the teacher’s role is to establish a strong sense of community. According to the NCTM (2000),

“Teachers play an important role in the development of students’ problem-solving dispositions by creating and maintaining classroom environments...in which students are encouraged to explore, take risks, share failures and successes, and question one another.

In such supportive environments, students develop confidence in their abilities and a willingness to engage in and explore problems and they will be more likely to pose

problems and to persist with challenging problems” (p. 52).

Another benefit is that writing activities “enable learners to make their mathematical thinking visible” (Whitin & Whitin, 2000, p. 17). It is through writing that teachers obtain a window into their students’ thinking (Albert & Antos, 2000). Teachers are able to identify error patterns and misconceptions prior to formal assessment. Early identification allows them to reteach immediately rather than waiting until after an exam when non-understanding generally surfaces (Miller & England, 1989).

Recently there has been a demand on our students to explain their mathematical processes in most of standardized testing. The Florida Comprehensive Assessment Test (FCAT) administered in grades five, eight, and ten, includes a mathematics component that is predominantly problem solving set in a context of other subjects. Students are required to respond to problems using “mathematically sound procedures and provide clear and complete explanations and interpretations” (Florida Department of Education, 2002).

Throughout my seven years of teaching, I have found that even the most astute students have difficulty communicating their procedures in problem solving. Too often children convey the correct answer, however, they do not know how they found the solution. On many occasions, I have presented challenging problems that students have been able to solve, yet they cannot explain their strategies for finding the answer. Because of the demand placed on students, I feel that it is necessary for children in my classroom to learn to explain their problem solving strategies and communicate their procedures more clearly through writing.

Purpose of the Study

The purpose of this study was to investigate the effectiveness of writing activities on students' achievement and attitudes towards problem solving in a fourth grade classroom. The two types of writing, transactional and expressive comprise a variety of methods: questions, explanations, word problems, letters, autobiographies, and journals.

Student writing activities will be assessed using a problem solving themed writing rubric (Appendix A) and student attitudes will be assessed using an attitude assessment survey (Appendix B). The purpose of this study is to examine the effects of my practice of using writing activities in mathematics on student's achievement and attitudes toward problem solving.

My research was designed to answer three specific research questions:

Research Question #1

How does my practice of integrating writing with mathematics affect my fourth grade students' achievement in problem solving?

Research Question #2

How does my practice of integrating writing with mathematics affect my fourth grade students' attitudes towards problem solving?

Research Question #3

Is there a relationship between students' attitudes in problem solving and their achievement in problem solving?

To build my confidence in the validity and reliability of my findings I decided to gather triangulated data for each of the three questions. Table #1 summarizes my triangulated data collection plan.

Table 1: Triangulation of Data Sources

RESEARCH QUESTION	DATA SOURCE #1	DATA SOURCE #2	DATA SOURCE #3
1. How does my practice of integrating writing with mathematics affect my fourth grade students' achievement in problem solving?	EARLY WRITING SAMPLE RUBRIC SCORES	TEACHER OBSERVATION	POST WRITING SAMPLE RUBRIC SCORES
2. How does my practice of integrating writing with mathematics affect my fourth grade students' attitudes towards problem solving?	PRE-ATTITUDE INVENTORY	TEACHER OBSERVATION	POST-ATTITUDE INVENTORY
3. Is there a direct relationship between students' attitudes in problem solving and their achievement in problem solving?	PRE-ATTITUDE SURVEY AND EARLY WRITING SAMPLE RUBRIC SCORES	TEACHER OBSERVATION	POST-ATTITUDE SURVEY AND POST-WRITING RUBRIC SCORES

Assumptions

This study was approached with the assumption that, by including writing activities into problem solving instruction, students' attitudes toward problem solving will improve. This assumption was based on a thorough review of the related literature as well as on my own professional experience. It was also assumed that students would do their best on the

performance tasks and written responses. The results of this study will begin to validate the use of additional time and resources needed to use writing activities in the mathematics classroom.

Definitions

For the purpose of this study, problem solving is defined as “engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings” (NCTM, 2000, p. 51).

The study incorporated two types of writing that enhance conceptual development: transactional writing and expressive writing. Expressive writing places emphasis on the process of writing and thinking (Rose, 1989). The forms of expressive writing used in mathematics classrooms are letter writing, autobiographical writing, and journal writing.

Transactional writing, most commonly found in the mathematics classroom is public in nature and intended to be read by an audience. Transactional writing takes the form of questions, explanations, and word problems. The main purpose is to inform, explain, or report concepts, processes, and applications (Rose, 1989).

Significance of the Study

“America’s schools are not producing the math excellence required for global economic leadership and homeland security in the 21st century” (U.S. Department of Education, 2005). Mathematics is a critical skill in the information age. For this reason, “We must improve achievement to maintain our economic leadership” (U.S. Department of Education, 2005). In

order to do so, we must ensure that schools employ scientifically based methods with long-term records of success to teach mathematics and measure student progress.

The “No Child Left Behind” Act requires that states align K-12 assessments with their academic standards for what students should know and be able to do. According to the plan, States, school districts, and schools must be accountable for ensuring that all students, including disadvantaged students, meet high academic standards. States must develop a system of sanctions and rewards to hold districts and schools accountable for improving academic achievement (U.S. Department of Education, 2005).

In accordance with “No Child Left Behind”, Florida has adopted challenging academic achievement standards for the tests in mathematics. The statewide assessment test, now known as the Florida Comprehensive Assessment Test or FCAT, is geared to the Sunshine State Standards and directly measures specific benchmarks that are part of the Standards.

Accountability is becoming increasingly important at the national and local level with a focus on mathematics. Writing activities foster responsibility, a sense of authority, and serve as a record of student progress over a predetermined period.

In the following chapter, I will investigate the trend of writing in problem solving and discuss the effects of infusing writing-to-learn strategies. I will explore the benefits of writing activities, especially the implications that such activities improve students’ achievement. In addition, I will examine the types of writing in problem solving and the constructivist ties to writing activities.

CHAPTER TWO: LITERATURE REVIEW

Introduction

In the past, mathematics was viewed as a subject in which the teacher, as authority figure, passed on information. The primary goal was to “develop student competency with arithmetic skills” (Burns, 1995, p. 6). Instructional time in mathematics employed the use of practice exercises from textbooks and the teacher acted as answer key. Traditionally, answers were either right or wrong and the primary goal was to elicit correct responses. Recently, much focus has been placed on problem solving and the thought processes, context, and understanding behind it (Miller, 1991).

Research indicates that writing has important implications for the learning and teaching of mathematics (Bell & Bell, 1985; Borasi & Rose, 1989; Miller & England, 1989; Clarke, Waywood, & Stephens, 1993; Rudnitsky, Etheredge, Freeman, & Gilbert, 1995). The review of the literature on writing in mathematics focused on the current trend of writing in problem solving and discussed the effects of infusing writing-to-learn strategies. I will examine the benefits of writing activities and the types of writing in problem solving. In addition, I will focus on the types of assessment used in problem solving and the constructivist ties to writing activities.

Problem Solving

According to the National Council of Teachers of Mathematics (NCTM, 2000) problem solving is a fundamental component of mathematics. This organization states that problem solving standards in instructional programs from prekindergarten through grade 12 should enable all students to-

- build new mathematical knowledge through problem solving,
- solve problems that arise in mathematics and in other contexts,
- apply and adapt a variety of appropriate strategies to solve problems, and
- monitor and reflect on the process of mathematical problem solving (p. 51).

Kenyon (1989) defines problem solving as “the process by which a person uses previously acquired knowledge and skills to attempt to find a resolution, not immediately apparent, to a situation (problem) that confronts him or her” (p. 76). Solutions are not readily available and students encounter disequilibrium. Engaging in problem solving provides students with repeated opportunities to devise, tackle, and explain difficult problems that involve considerable effort (NCTM, 2000). “Good problems give students the chance to solidify and extend what they know and, when well chosen, can stimulate mathematics learning” (NCTM, 2000, p. 51).

According to Countryman (1992), students need to “know and to understand the advantages of different methods of obtaining answers. They need to know when to guess, when to use pencil and paper, when to use a calculator, how to recognize an answer, and whether the answer makes sense” (p. 9). In a study of 29 college mathematics students, which examined the potential benefits of journal writing for mathematics instruction, Borasi and Rose (1989) found “an increased awareness of the process of doing mathematics seems especially important for the

students' success in mathematics" (p. 356). Throughout the study period, students were asked to write three entries per week. By asking students to report in their journals, Borasi and Rose (1989) discovered how students solved a problem or approached the study of a topic. The researchers found students can "be encouraged to become introspective of how they do and learn mathematics, and consequently, be brought to identify more general heuristics to solve mathematics problems as well as to realize the possibility of alternative approaches to the same learning task" (p. 356).

Reflection is another key component of problem solving. Silver et al. (1990) place much emphasis on reflection. In their text, they state:

Our thoughts are ephemeral creatures that won't be pinned down until we articulate them in speech or writing. It is only when we have said or written them, and then have reflected on them, that we know what we are thinking (p. 21).

Consequently, because we do not retain much of what we see and hear in mathematics until we have appropriated it on our own, reflection enables students to group their thoughts and "get it out into the open or pin it onto the page" (Silver et al., 1990, p. 21). Once there, students are enabled to examine, repair, or augment their thinking.

Burns (1995) suggests classroom lessons should help students learn to use a variety of strategies to solve problems, to verify and interpret results, and to generalize solutions to new problem situations. Writing requires students to formulate and clarify their ideas and, therefore, can contribute to helping students develop these abilities (p. 69). Whitin and Whitin (2000) assert that writing provides students with a record of their thinking that can be analyzed and reflected upon, thus enabling students to develop a personal voice.

Clarke, Waywood, and Stephens (1993) conducted a four- year teaching experiment, which explored the implications of the regular completion of student journals in mathematics. “It was intended that journal writing would assist students progressively to engage in an internal dialogue through which they reflected on and explored the mathematics they met” (p. 237). According to their research, students initiated questions about what they were doing, and demonstrated increasing confidence in using their own words to link ideas. They were able to make suggestions about possible ways to solve problems, even if these approaches did not prove to be successful. “Through their writing, they showed that they are actively constructing mathematics” (p. 248).

Communication

The Principles and Standards for School Mathematics (NCTM, 2000) emphasize communication as a vital component of mathematics and mathematics education.

Communication Standards in instructional programs from prekindergarten through grade 12 should enable all students to-

- organize and consolidate their mathematical thinking through communication;
- communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
- analyze and evaluate the mathematical thinking and strategies of others;
- use the language of mathematics to express mathematical ideas precisely (p. 60).

Classrooms that foster communication enable children to “generate ideas, develop a personal voice, and reflect upon their current understandings” (Whitin & Whitin, 2000, p. 6). In addition,

such classrooms enable students to speak about their thinking – to discuss observations, explain procedures, and justify that their solutions are correct (Silver et al., 1990). Through this process, students find out what they know and what they do not know. “As students communicate their ideas, they learn to clarify, refine, and consolidate their thinking” (Whitin & Whitin, 2000, p.6).

It is especially important that students share their thoughts clearly and completely to their peers and teachers. By testing their ideas and sharing knowledge in the classroom, students are able to see if their thoughts are understandable. As indicated by the NCTM (2000), “when students are challenged to think and reason about mathematics and to communicate the results of their thinking to others...they learn to be clear and convincing” (p.59).

Furthermore, students must have opportunities to listen to the strategies and ideas of others in order to test their own mathematical thinking. Silver et al. (1990) posit, “The only way we have of knowing what our thinking is like is by comparing it with that of others” (p. 23). By listening to others, students gain multiple perspectives, which allow them to make connections and gain better mathematical understanding (NCTM, 2000).

Finally, in order to express ideas precisely, students must use mathematical vocabulary, notation, and structure. Connolly (1989) states “language, oral or written, is an expressive instrument through which we communicate what we have previously thought. It is also a reflective instrument through which we think, alone or with others, about what we are doing” (p. 9).

In a study of 401 third-grade and fourth-grade students, Rudnitsky et al. (1995) designed and field tested instruction intended to help students construct knowledge about addition and subtraction story problems. The method of instruction that was developed and reported on in the study adhered to an important guiding element, that children, building on existing knowledge,

actively construct new knowledge through their experience and interactions with the environment” (p. 468). The researchers contend, “The context in which learning is embedded is important. At least some understandings...are negotiated in a social and cultural context. Our instruction recognizes that the most powerful and productive thinking may be done with others and attempts to create a culture of collaboration and thinking aloud” (p. 468). As a result, teachers reported a significant increase in mathematical discourse among students. Through mathematical discussions, students acquired knowledge of word-problems and transferred this knowledge to problem solving.

Benefits of Writing Activities

Research has shown that there are many benefits associated with the mathematics writing connection (Bell & Bell, 1985; Miller & England, 1989). Writing activities provide an open, accessible avenue of communication between teachers and students; impart a window to students’ understanding; provide students with a personal voice; and promote a sense of ownership and responsibility for one’s thoughts.

Unfortunately, no classroom teacher has time to interact individually with each student for five minutes every day. However, writing activities provide an avenue of communication between teachers and students that are accessible on a daily basis. Students may convey their thoughts about class, about what they are learning, and may even write about themselves as learners. Miller (1991) declares “A timed, classroom writing session gives the teacher the opportunity to know what each student is thinking during that time and, often, the opportunity to get to know more about each student as a person and a learner” (p. 518).

In an exploratory investigation to ascertain the influence of the use of regular writing in algebra class, Miller and England (1989) conducted an investigation, which studied the effect of regular writing in algebra classes on students' attitudes and skills in algebra. In addition, researchers examined the influence of reading students' regular, written work on the teachers' awareness of students' problems in and attitudes toward algebra. As part of the study, the teachers were required to spend time each week reviewing students' writings and provide the faculty with their own writings, which would reflect dominant impressions drawn from the students' writings. Following a particular prompt which assessed students' understanding of the rules or "Order of Operations", teachers learned "that just because a student can quote a rule or property does not necessarily mean that they know how to apply the rule or property" (p. 304). Thus, the students' writing increased teachers' understanding.

Because of their confidential nature, writing activities take the focus away from individual students, allowing them to write without drawing attention from their peers. Miller (1991) states, "given the opportunity to write about their understanding, or lack of understanding, of mathematics, students who will not ask questions in class may express their confusion privately in writing" (p. 518). In 1984, Bell and Bell conducted a study that investigated the effects of a program that combined expository writing with instruction in mathematic problem solving using two ninth-grade general mathematics classes. One class was used as an experimental group, which taught problem-solving skills by using a method combining traditional mathematics techniques with a structured expository writing component. The second class, the control group, was taught only the traditional mathematics methods. According to their findings "through writing, students can communicate to the teacher, either directly or indirectly when they are having difficulty understanding the material" (1985, p. 219). If students

are confused, writing will force them to try to discover what is bothering them. As a follow-up, they recommend that students write an explanation of how they overcame their confusion. Having students write explanations, or tell why they cannot do so, provide a window on their understanding of the material. In turn, information is provided on how the lesson is being received and which material needs to be reinforced (Meier & Rishel, 1998).

In addition, when students begin studying a new mathematical concept, teachers often assume that students know very little about the topic. In actuality, students may have formed some rather complete, although possibly partially mistaken ideas about the topic. “One way to detect and examine the ideas students may have prior to formal instruction is to provide a writing assignment” (Silver, et al., 1990, p. 20). “Through this process, the teacher becomes aware at a deeper level of the common understandings or misunderstandings that are characteristic of their students” (Silver et al., 1990, p. 21).

Another benefit of writing in mathematics is that it instills a sense of responsibility in students. Following their study of 500 secondary students, Year 7 to Year 12, Clarke, Waywood, and Stephens found that articulating their own thinking empowered students. By encouraging students to convey what they have learned puts them in charge of their own thinking. Clarke et al. (1993) contend, “The key appears to be to encourage students to question themselves when they do not understand rather than be dependent upon their teacher to tell them whether to understand. This requires an internalization of authority, responsibility, and control” (p. 248).

Additionally, attitudinal benefits evoke from writing activities. Through constant reflection, students develop a sense of confidence in the mathematics at hand (Albert & Antos, 2000). “Students begin to question what they are doing, and show increasing confidence using their own words to link ideas” (Clarke et al., 1993). They are also able to relate the real world

with mathematical concepts. Albert and Antos (2000) proclaim, “As mathematics becomes relevant, students become more motivated to learn and more interested in the learning process” (p. 526).

Types of Writing

“Writing to learn” in science or mathematics classes is most about developing students’ conceptual understanding of these subjects by developing their capacity to use the languages of these fields fluently. The writing-to-learn movement is fundamentally about using words to acquire concepts. It is about the value of writing “to enable the discovery of knowledge” (Connolly, 1989, p. 5). Within this framework are two types of writing that enhance conceptual development: transactional writing and expressive writing.

Transactional writing, most commonly found in the mathematics classroom is public in nature and intended to be read by an audience. Transactional writing takes the form of questions, explanations, and word problems. The main purpose is to inform, explain, or report concepts, processes, and applications (Rose, 1989).

The main purpose of question writing tasks is to elicit from students what they do not understand. There are many different ways to incorporate this method. Teachers may collect student-generated questions at the beginning of class and address their issues immediately. This technique provides students with an immediate response and may be used as a springboard for the day’s lesson. Teachers may also write back to the student later and provide clarification and suggestions for the student (Rose, 1989). By providing a written response, valuable classroom

time can be saved for issues of greater concern while still addressing individual student needs (Bell & Bell, 1985).

Explanations are an effective way to evaluate student understanding (Bell & Bell, 1985; Rose, 1989). Teachers may ask students to write how they solved a particular problem or explain any challenges they may have encountered (Rose, 1989). During their study, Bell and Bell (1985) required students to formally record the problem-solving steps they experienced and to make judgments about them. The writing assignments asked students to concentrate on the process they used in solving specific problems. This process allows students to put into words what they understand and do not understand thus providing teachers with insight into students' conceptual understanding.

Another form of transactional writing, problem creation, entails students writing their own problems or changing existing problems. This process enables students to see how problems are constructed and helps them learn to deal with situations in which appropriate mathematical ideas and techniques are not obvious (Silver et al., 1990). As part of their study, Rudnitsky et al. (1995) incorporated several lessons, which engaged students in the creation of mathematical stories and story problems. The researchers maintain, "To write a comprehensible problem, a student presumably must understand the concept underlying the problem" (p. 470). This valuable teaching technique demonstrates students' understanding of the concept underlying the self-created problems (Rudnitsky et al., 1995).

Expressive writing places emphasis on the process of writing and thinking (Rose, 1989). The forms of expressive writing used in mathematics classrooms are letter writing, autobiographical writing, and journal writing.

As stated by Rose (1989) “Letter writing has several advantages over other writing tasks; students are familiar with writing letters, like to have an audience for their writing, and feel comfortable including both affective and cognitive thoughts” (p. 23). Students can express thoughts and feelings about mathematics, explain procedures to an absent child, or ask advice on how to solve a particular problem. Following their study, which shared the experiences of secondary teachers who used writing to learn algebra, Miller and England (1989) indicated, “Students seem to write more if they address their comments to someone” (p. 308) like a friend or a past teacher.

Autobiographical writing is comfortable for students because it gives them permission to write about something with which they are familiar (Countryman, 1992). This form of writing encourages students to share previous experiences in addition to responding to structured questions. Through this process, students realize that writing is a “vehicle by which they can recognize feelings and experiences and that the written product can become a record for referral and reflection” (Rose, 1989, p. 24). Furthermore, as students write about their mathematical background they “come to see themselves as central to the process of learning” (Countryman, 1992, p. 22). It is important for teachers to realize that “students’ early school experiences with learning mathematics are critical for forming their basic attitudes and understandings” (Burns, 1995, p. 5).

Journals are multifaceted and address a variety of individual classroom and teacher needs. Subject matter may include summaries, explanations, and questions regarding specific content, descriptions of mathematical procedures, solution strategies, and feelings about class, mathematics, and the teacher (Rose, 1989). One benefit associated with journal writing is that it

“gives students time to think at their own rate and to internalize new concepts by relating them to their own experiences” (Kenyon, 1989, p. 84).

Assessment

Assessment is a valuable way to monitor student progress and clarify teacher expectations (Charles, Lester, & O’Daffer, 1988; Danielson & Hansen, 1999). These measurements provide feedback to students regarding their progress; offer parents evidence of their children’s level of functioning; and enable teachers to determine whether the activities accomplished their intended goal (Danielson & Hansen, 1999).

According to Danielson and Hansen (1999) “Performance assessment is any assessment of student learning that requires the evaluation of student writing, products, or behavior” (p.1). Assessments take many forms and accomplish a variety of purposes. Written products include essays, journal entries, and reports. Additionally, behavior assessments provide students with opportunities to demonstrate their knowledge or skill through their behavior (Danielson & Hansen, 1999).

Danielson and Hansen (1999) emphasize the importance of performance task rubrics to evaluate student learning and student work. They suggest educators can save time and effort by adapting existing tasks and rubrics to their own use. Through this approach, teachers benefit from the work of others while using a task that reflects their own needs.

Charles et al. (1988) contend that your plan for evaluating progress in problem solving should build on the goals you select. In their research, Charles et al. (1988) discuss several important goals for teaching problem solving and provide effective evaluation techniques to

assess these goals. Furthermore, great importance is placed on the evaluation of students' progress in problem solving in two major areas: performance in using a variety of problem-solving skills and strategies, and attitudes and beliefs regarding problem solving. Several techniques for evaluating these outcomes include observing and questioning students, using assessment data from students, and using analytic scoring techniques.

Informal observation and questioning allows the evaluator to observe individuals, small groups, or whole classes solving problems while asking evaluative questions and recording observations (Charles et al., 1988). This method can be used to assess both performance and attitudes and beliefs and is associated with many benefits:

- It allows for evaluation in a natural classroom problem-solving setting.
- It is flexible, allowing for evaluation of only a few students at a time.
- It allows for evaluation focused on limited, specific aspects of student behavior.
- It allows for evaluation of aspects of performance and attitude that are difficult, if not impossible, to evaluate using other techniques.
- It provides a record of observed growth in the development of specific problem-solving skills and attitudes and a check on evaluations using other methods (p. 19).

Structured interviews also involve observation and questioning, however the interview is usually limited to one student. Although structured interviews take a great deal of time, this method allows the evaluator the opportunity to ask probing questions and allows for responses more elaborate in nature. This technique permits students to give detailed responses regarding what they are thinking and doing and provides "insight into a student's thinking processes that are not usually apparent from written work" (Charles et al., 1988, p. 22).

Another technique for evaluating problem-solving performance and attitude goals incorporates self-assessment data from students. One method, student report, instructs students to write about a problem-solving experience. Students reflect on a situation and describe how they solved the problem. A general prompt, such as “Tell about your thinking as you describe how you solved the problem,” may help the student get started (Charles et al., 1988, p. 24).

Inventories are another type of self-assessment in which students check from a list of items to provide a self-appraisal of performance or attitudes. Charles et al. (1988) maintain, “Inventories are especially useful for measuring student attitudes and beliefs related to problem solving” (p. 29). Using inventories allow students input into the evaluation process and require little of the teacher’s time for collecting data.

Finally, Charles et al. (1988) consider how a student’s written work on a problem can be used to assess development in problem solving. Analytic scoring incorporates an assigned scale of points to certain phases of the process. This scoring method allows the teacher to pinpoint specific areas of strength and weakness and provides specific information about the effectiveness of various instructional activities.

A Constructivist Approach

Often, we encounter objects, ideas, and problems that are unfamiliar to us. Brooks and Brooks (1993) maintain when such a discrepancy occurs “we either interpret what we see to conform to our present set of rules for explaining and ordering our world, or we generate a new set of rules that better accounts for what we perceive to be occurring” (p. 4). This process of equilibration is how people come to know about their world (Brooks & Brooks, 1993).

Jean Piaget was a genetic epistemologist concerned primarily with cognitive development and the formation of knowledge. “His research led him to conclude that the growth of knowledge is the result of individual constructions made by the learner” (Brooks & Brooks, 1993, p. 25). Piaget (1971) wrote:

The current state of knowledge is a moment in history, changing just as rapidly as knowledge in the past has changed, and, in many instances, more rapidly.

Scientific thought, then, is not momentary; it is not a static instance; it is a process. More specifically, it is a process of continual construction and reorganization (p. 2).

In his discussion on constructivism, a theory of knowledge that explains how we know what we know, Zahorik (1997) posits, “knowledge ...changes as we engage in new experiences that test what we know. These new experiences may cause us to alter or add to our understanding, sometimes in subtle ways and sometimes dramatically” (p. 30).

Learning in mathematics also involves a sense-making process. Connolly (1989) asserts, “Learning involves manipulating, not just memorizing, inert information” (p. 3). “It involves listening to the mathematics teacher, but it also involves ‘making sense’ for oneself: producing, applying, and extending knowledge in the way a mathematician or scientist does” (p. 3). All of us are constantly engaged in this process in our everyday lives, but this is also the process that scholars in every discipline follow. “They seek new experiences to test, and they subsequently construct knowledge through inquiry and scholarly dialogue” (Zahorik, 1997, p. 30).

“In contrast to traditional instruction, current practices for effective mathematics teaching call for actively engaging children with mathematical experiences that help them make sense of mathematical ideas” (Burns, 1995, p. 9). It is the teacher’s role to create a learning environment

that fosters the construction of knowledge and this sense-making process (Brooks & Brooks, 1993). In order to do so, teachers must provide a wealth of opportunities for students to work together collaboratively (Brooks & Brooks, 1993). By working in small groups, students benefit from hearing other perspectives and seeing the way that others learn. In turn, “teachers create a classroom culture within which cooperative learning will flourish, and where students feel able to take intellectual risks without fear of punishment, embarrassment, or reprisal” (Alkove & McCarty, 1992, p. 18).

NCTM (2000) contend “teachers play an important role in the development of students’ problem-solving dispositions by creating and maintaining classroom environments...in which students are encouraged to explore, take risks, share failures and successes, and question one another” (p. 52). “In such supportive environments, students develop confidence in their abilities and a willingness to engage in and explore problems and they will be more likely to pose problems and to persist with challenging problems” (NCTM, 2000, p. 52). Teachers must also inquire about students’ understandings of concepts and allow their responses to “drive lessons, shift instructional strategies, and alter content” (Brooks & Brooks, 1993, p. 105).

Students come to mathematics class having a variety of real-world experiences on which to continue the construction of their knowledge of mathematics (Miller, 1991). Miller (1991) asserts, “The construction of knowledge requires active engagement in thought-provoking activities. Because writing leads people to think, improved mastery of mathematics concepts and skills is possible if students are asked to write about their understanding” (p. 517). In contention with constructivist views, Borasi and Rose (1989) claim that writing activities “can also positively influence the student-teacher interaction and classroom atmosphere; when students and teachers freely communicate and see each other as caring human beings, the classroom can

turn into a more pleasant environment where all members become partners in learning” (Borasi & Rose, 1989, p. 363).

Summary

Research indicates writing activities enhance students’ understanding in problem solving. The review of literature illustrates writing in mathematic genres promotes students’ self-worth, provides daily opportunities for communication between teachers and students, and provides an avenue for teachers to evaluate students’ conceptual development. In addition, rubric assessments and performance tasks are valuable techniques for measuring student progress. Assessments assume many forms and achieve a range of purposes. Furthermore, writing activities foster constructivist ideology and create learning that is more meaningful. Students are enabled to reflect upon previous knowledge and prior experiences in order to revise and rework these ideas to form new knowledge in problem solving.

CHAPTER THREE: METHODOLOGY

Introduction

Using an action research model, I conducted a study in the fall of 2004 to determine the effects of writing activities on students' attitudes and achievement in problem solving. A goal of the study was to discover improvements in students' performance and attitudes on problem solving activities and the relationship between attitudes and performance in problem solving. The study stretched over a six-week period, beginning in October 2004 and ending in December 2004. I wanted to examine my belief that writing activities contribute to higher performance and better attitudes toward problem solving. The action research model systematically demanded that I reflect on my practices of using writing activities in problem solving in an effort to improve my teaching practices.

According to Mills (2000), action research is defined as “any systematic inquiry conducted by teacher researchers...in the teaching/learning environment to gather information about how their particular schools operate, how they teach, and how well their students learn” (p. 5). The purpose of action research is to gain insight, employ reflective practice, promote positive changes in the school environment, and improve student outcomes and the lives of those involved.

Research Setting

The study took place at an elementary school comprising 536 students located in an urban area of Central Florida. The following descriptions pertain to the school's student population using October 2004 membership. Gender divisions were as follows: 261 females and 275 males, 48.7% and 51.3%, respectively. Racially, the school comprised the following: 310 white or 57.8% of the school's population, 177 black or 33%, 29 Hispanic or 5.4%, and 9 Asian or 1.7% of the school's population. Forty-two percent of the students received free or reduced price lunch.

My study took place in my fourth-grade classroom. I am an intermediate elementary teacher who teaches all subject areas. There are three fourth-grade classes at our school. The specific population targeted for this study was my own fourth-grade class. Class lists for the three anticipated fourth grades were randomly selected by the principal from the third-grade list of students going on to fourth grade. New students were added to the class lists as students enrolled at the start of our 2004-05 school year. Every attempt was made to balance the numbers in the three classes during the school year as students withdrew and enrolled.

Two of the students were repeating fourth grade and seven students were in the enrichment program. FCAT Achievement Levels in mathematics are as follows: five students scored a Level 5, six students scored a Level 4, seven students scored a Level 3, five students scored a Level 2, and two students scored a Level 1. In accordance with the No Child Left Behind Achievement Standards, Level 5 is advanced, Levels 3-4 are proficient, Level 2 is basic, and Level 1 is below basic. During the course of the study, one student involved in the study

withdrew from the school and one student entered my classroom after the study began. Twenty-five students were part of my study from beginning to end.

Procedures

Prior to beginning the study, International Review Board (IRB) permission was sought and obtained (Appendix C). Permission was acquired from the principal of the school to conduct the action research study in my classroom (Appendix D). Subsequently, I requested parental consent (Appendix E) for each of my students. After obtaining permission from their parents, I asked each of my students for their assent to do this study (Appendix F). I explained my requirements and provided an opportunity for students to ask any questions they may have. Once I received permission from the parents and the students gave their assent I proceeded with the study.

Two activities were conducted at both the beginning and the end of the research period. At the beginning of the research period, students in the group completed the NCTM Attitude Inventory (Charles, Lester, & O'Daffer, 1987). The Attitude Inventory is a simple true-false checklist, which assesses students' willingness to engage in problem-solving activities, perseverance during the problem-solving process, and self-confidence with respect to problem solving. Items are worded to reveal positive or negative feelings. For each negatively worded item, a zero was assigned if marked "true" and one if marked "false." For each positively worded item, a zero was assigned if marked "false" and one if marked "true." Permission was

granted to use the attitude inventory from the National Council of Teachers of Mathematics (Appendix G).

Throughout the research period, participants responded to a variety of writing assignments. Within the writing to learn framework, two types of writing were used: transactional writing and expressive writing. Students wrote their own word problems and used their journals to ask questions they had regarding assignments. In addition, students were asked to write a mathematical autobiography in which they shared previous experiences and their feelings about mathematics. Finally, the journals were utilized to elicit solution strategies and steps for assigned problems.

Each student kept a spiral notebook to solve a variety of problems (Appendix H). Each day, students were presented with a problem and were encouraged to design a plan and document their findings. Students solved problems both independently and as part of collaborative groups. At the start of each session, students were given 15 – 20 minutes to solve their problems and record their strategies. Upon collection of the journals, students took turns sharing their solution strategies with the class. Discussion sessions generally lasted about 15 minutes.

Journal entries were scored using a problem solving themed rubric and returned to students. Students were provided opportunities to respond to their scores, communicate their thoughts to the researcher, and revise their solution strategies.

At the end of the research period, the students were given the NCTM Attitude assessment. Again, the Attitude Inventory Assessment was scored using guidelines from the NCTM (1987) *How to Evaluate Progress in Problem Solving*. The Attitude Inventory was selected for its accessibility, reliability, and ease of scoring.

Data Collection

The triangulation of data used in this research increased credibility and trustworthiness of the results. The triangulation included student entries in mathematics journals, pre- and post-writing rubric scores, pre- and post- attitude inventories, and field notes of teacher observations. To build my confidence in the validity and reliability of my findings I decided to gather triangulated data for each of the three questions. Table #2 summarizes my triangulated data collection plan.

Table 2: Triangulation of Data Sources

RESEARCH QUESTION	DATA SOURCE #1	DATA SOURCE #2	DATA SOURCE #3
1. How does my practice of integrating writing with mathematics affect my fourth grade students' achievement in problem solving?	EARLY WRITING SAMPLE RUBRIC SCORES	TEACHER OBSERVATION	POST WRITING SAMPLE RUBRIC SCORES
2. How does my practice of integrating writing with mathematics affect my fourth grade students' attitudes towards problem solving?	PRE-ATTITUDE INVENTORY	TEACHER OBSERVATION	POST-ATTITUDE INVENTORY
3. Is there a direct relationship between students' attitudes in problem solving and their achievement in problem solving?	PRE-ATTITUDE SURVEY AND EARLY WRITING SAMPLE RUBRIC SCORES	TEACHER OBSERVATION	POST-ATTITUDE SURVEY AND POST-WRITING RUBRIC SCORES

Analysis

The analysis of the data included the scoring of the pre- and posttest Attitude Inventory Assessment, and the problem solving themed writing rubric assessments. It was the researcher's hope that as the writing rubric scores showed better understanding of problem solving, the students' attitudes about problem solving would improve.

The Attitude Inventory Assessment was given to the participants at the beginning and the end of the study. The three categories assessed were willingness to engage in problem-solving activities, perseverance during the problem-solving process, and self-confidence with respect to problem solving. Items were worded to reveal positive or negative feelings. For each negatively worded item, a zero was assigned if marked "true" and one if marked "false." For each positively worded item, a zero was assigned if marked "false" and one if marked "true." An average score for each question on the pre- and post- Attitude Inventory was determined. The average score on each Attitude Inventory scale was placed in an Excel spreadsheet. The average score for the pre-assessment was compared to the score of the post-assessment to determine any difference in attitude toward problem solving.

The quality of problem solving writing was documented by tracking the writing assignments. Solution strategies were scored by using a Problem Solving Rubric found in Arter and McTighe (2001) *Scoring rubrics in the classroom: Using performance criteria for assessing and improving student performance*. Permission was sought and obtained to use the analytic rubric (Appendix I).

Students' responses to problems were graded in each of three categories: mathematical knowledge, strategic knowledge, and explanation. The three category scores were averaged to

get a combined rubric score for the journal entry. Adding the three scores together and dividing by three provided an average rubric score. Early writing sample scores were compared to post writing sample scores to determine if there was a difference in the level of student performance.

Limitations

There were limitations to this study that affected the generalization of the findings to other classrooms. One limitation was the type of students involved in the study. The target population of all fourth grade students was reduced to an available population of fourth grade students assigned to the researcher's fourth grade classroom in Orlando, Florida. Another limitation of this study was student participation in every journal writing activity used in the study. Throughout the study, there were student absences, incomplete assignments, and students out of the classroom during class time for unexpected reasons. A further limitation was the length of the research period. Due to time constraints and missed days resulting from three hurricanes, I was only able to observe my students over the course of six weeks. The hurricanes resulted in a loss of school time and disruption in the school year, forcing me to begin my study later than I had anticipated. Furthermore, improvements in problem solving skills were expected regardless of writing integration.

CHAPTER FOUR: DATA ANALYSIS

Introduction

The purpose of this study was to determine if writing activities had an effect on student achievement and attitude toward problem solving. I have recently gained interest in this topic because of my coursework through the Lockheed Martin Academy and because of the importance placed on written explanation in mathematics on the Florida Comprehensive Achievement Test. The study focused on three main principles:

1. How my practice of integrating writing with mathematics affects my fourth grade students' achievement in problem solving;
2. How my practice of integrating writing with mathematics affects my fourth grade students' attitudes toward problem solving; and
3. Whether there is a direct relationship between students' attitudes in problem solving and their achievement in problem solving.

I eagerly approached my study with the possibility of validating a teaching practice that would help increase my students' performance in problem solving and improve students' attitudes toward problem solving.

Data were collected from three different sources related to students' attitude and performance in order to triangulate the subsequent findings. Data were analyzed from pre- and post-attitude inventories, problem solving rubrics and student journal entries, and anecdotal records.

Research Question #1: Student Achievement

Question 1: How does my practice of integrating writing with mathematics affect my fourth grade students' achievement in problem solving?

This study focused on how integrating writing with mathematics affected student performance in problem solving. Data were collected from three main sources in order to triangulate the findings. The first two sources involved analysis of student journal entries through use of a problem solving themed rubric. Early writing rubric scores were compared to recent writing rubric scores to determine whether an increase in performance occurred.

Each student kept a spiral notebook to solve a variety of problems. Each day, students were presented with a problem and were encouraged to design a plan and document their findings. Many problems were intended to be solved independently, while others were meant to be worked on in cooperative groups. At the start of each session, students were given 15 – 20 minutes to solve their problems and record their strategies. Upon collection of the journals, students took turns sharing their solution strategies with the class. Discussion sessions generally lasted about 15 minutes.

The quality of problem solving writing was documented by tracking the writing assignments. Solution strategies were scored by using a Problem Solving Rubric (Appendix A) found in Arter and McTighe (2001) *Scoring rubrics in the classroom: Using performance criteria for assessing and improving student performance*. Students received a score from zero to four in each of three categories: mathematical knowledge, strategic knowledge, and explanation. The three category scores were averaged to get a combined rubric score for the journal entry. An average rubric score was calculated by adding the three scores together and

dividing by three. Early writing sample scores were compared to post writing sample scores to determine if there was a difference in the level of student performance. These data, along with anecdotal records were used to show the effects of journal writing on students' achievement in problem solving.

Mathematical Knowledge

The Problem Solving Rubric assessed students' mathematical knowledge, strategic knowledge and explanation. In the category of mathematical knowledge, students were evaluated on their knowledge of mathematical principles and concepts, which result in a correct solution to a problem. These data were separated into one-week increments and analyzed. For each week, student's scores in the category of mathematical knowledge were calculated to determine a mean score. These data were used to categorize students in one of three performance ranges: above average, average, and below average. Mean scores ranging from 3.75 to 4.0 were considered above average, scores ranging from 3.0 to 3.5 were considered average, and scores of 2.75 and lower were considered below average. To determine the ranges in score, I divided each possible score by 4 to come up with a percentage. 3.75 to 4.0, the equivalent of 93% to 100% was considered above average according to our school grading scale. 3.0 to 3.5, the equivalent of 75% to 87% was considered average according to our school grading scale. 2.75 and below, the equivalent of 68% and lower was considered below average according to our school grading scale. Table 3 represents the average rubrics scores in the category of mathematical knowledge for the six-week research period.

Table 3: Summary of Results for Mathematical Knowledge

	Students with Above Average Scores		Students with Average Score		Students with Below Average Score	
	Percent of Class	Percent of Class	Percent of Class	Percent of Class	Percent of Class	Percent of Class
Week 1	11	44%	8	32%	6	24%
Week 2	14	56%	9	36%	2	8%
Week 3	2	8%	10	40%	13	52%
Week 4	9	36%	10	40%	6	24%
Week 5	2	8%	8	32%	15	60%
Week 6	2	8%	9	36%	14	56%

Analysis of rubric scores indicated little growth in students' achievement in the category of mathematical knowledge. The number of students with above average scores decreased over the six-week study. In addition, there was an increase in the number of students with below average scores. Moreover, the amount of students with average scores stayed relatively the same.

As I analyzed anecdotal records, I looked for behaviors and comments regarding students' performance during the problem solving process. Specifically, I was seeking notes regarding application of students' mathematical knowledge in multiplication and fractions. Regular observations highlighted students by number, with my notes about their abilities in these areas.

Anecdotal records and analysis of student journal entries provided opposing information. Prior to the study, a majority of students demonstrated weak multiplication skills. Over the course of the study, new multiplication algorithms were introduced. Journal entries and field notes indicated that most of the students were able to incorporate these new concepts into their

solutions. Student 10 communicated, “I like multiplication because I’m getting to learn more multiplication.” Student 12 expressed, “I like logic and addition and division and also multiplication because all of that stuff is easy to me.” Finally, Student 11 indicated, “I think that problem solving is great because it help with my math like time tables, fractions and other math things.”

Consequently, students were better able to execute multiplication algorithms. Student 14 had little prior knowledge of multiplication concepts when he entered fourth grade. As a result, he struggled throughout the first semester. As he learned new skills, he incorporated them into his solution strategies. Later journal entries supported his newfound knowledge evidenced by his use of the lattice method and partial products method of multiplication.

Furthermore, as a culminating activity, I introduced a fairy tale story problem (Appendix J) that integrated fraction mathematical knowledge. Upon completion, students were asked to create their own story problems. Nine of the 25 students, or 36% composed story problems with a fraction theme. Following are several examples:

Student 3 wrote:

There once was a boy, that for Christmas got a velveteen rabbit. Out of all the toys he got that day, the rabbit was the best. For at least two hours the little boy loved him. How long is $\frac{1}{6}$ of two hours?

Student 21 wrote:

It was a bright sunny day at the Daytona 500. Jeff Gordon was in the lead when he realized he had a flat tire. While they were changing the flat tire, they realize that $\frac{2}{4}$ of the bolts on his tires had fallen off. If there are six bolts on each wheel, how many bolts fell off?

Student 23 wrote:

Once upon a time, there was a poor villager, who only had 18 worthless beans.

One day when he was walking to the market he met a wise elderly man who sold his gold laying hen for one-sixth of the beans. So then the next day he met the same man who said, "I'll give you 3 gold bars for one third of your beans." So they made a trade. Then the next day he stumbled upon the wise man and said, "I'll give you this lovely golden harp for one half of your beans." How many beans did the villager have left?

Student 13 composed a Cinderella themed story. The fourth problem in her story reads:

Finally, she was at the ball.

Wanting to dance with the finest of all.

There stood 12 men fine and tall.

She took $\frac{2}{6}$ of the men and danced

While she danced, she had a ball.

How many men did she dance with in all?

Although some problems are integral parts of the story, and many are more extensive than others are, I believe students demonstrated growth in their mathematical knowledge of fractions.

The remainder of the class implemented other types of problems similar to their daily journal problems. Students addressed time concepts, multi-step problems, and logic problems.

Review of the assignment indicated that students demonstrated mathematical knowledge on many different types of problems.

Finally, anecdotal records suggested that students exhibited broader mathematics vocabulary as a result of writing about mathematics. Students frequently assisted each other

during problem solving activities and discussed the mathematics at hand. Students were generally on task and were noticed explaining and clarifying ideas to their partners.

Strategic Knowledge

In the category of strategic knowledge, students were evaluated on their identification of important elements of the problem and the use of models, diagrams, symbols, and/or algorithms to systematically represent and integrate concepts. These data were separated into one-week increments and analyzed. For each week, student's scores were calculated to determine a mean score. These data were used to categorize students in one of three performance ranges: above average, average, and below average. Mean scores ranging from 3.75 to 4.0 were considered above average, scores ranging from 3.0 to 3.5 were considered average, and scores of 2.75 and lower were considered below average. To determine the ranges in score, I divided each possible score by 4 to come up with a percentage. 3.75 to 4.0, the equivalent of 93% to 100% was considered above average according to our school grading scale. 3.0 to 3.5, the equivalent of 75% to 87% was considered average according to our school grading scale. 2.75 and below, the equivalent of 68% and lower was considered below average according to our school grading scale. Table 4 represents the average rubrics scores in strategic knowledge for the six-week research period.

Table 4: Summary of Results for Strategic Knowledge

	Students with Above Average Scores	Percent of Class	Students with Average Scores	Percent of Class	Students with Below Average Scores	Percent of Class
Week 1	12	48%	8	32%	5	20%
Week 2	14	56%	8	32%	3	12%
Week 3	0	0%	10	40%	15	60%
Week 4	7	28%	12	48%	6	24%
Week 5	2	8%	6	24%	17	68%
Week 6	4	16%	6	24%	15	60%

Analysis of rubric scores indicated little growth in students' achievement in the category of strategic knowledge. The number of students with above average scores decreased over the six-week study. In addition, there was an increase in the number of students with below average scores. Moreover, the amount of students with average scores stayed relatively the same.

Due to limited exposure to problem solving, students had little prior knowledge of solution strategies prior to beginning the study. Multi-step problems and problems involving several solutions proved to be challenging for many students. One indicator was that students did not identify all the important elements of the problem. Many identified some important elements, even most of the important elements, yet failed to demonstrate understanding of the relationships among elements.

In contrast to the rubric, anecdotal records and analysis of students' response journals provided a window to students' thinking and strategic knowledge. Teacher field notes revealed numerous occasions where students utilized manipulatives to assist in their solution strategy.

During our sharing sessions, students provided a variety of strategies for finding solutions. One problem in particular elicited a number of ideas:

A farmer has 15 animals, some pigs and some chickens. Together, they have a total of 40 legs. How many pigs and how many chickens does the farmer have?

Of the 25 participants, four students, or 16% executed a guess, check, revise strategy. Two students or 8% accomplished the problem by writing a number sentence. Twelve students or 48% constructed a chart or a diagram. Two students, 8%, carried out their strategy through a combination of number sentences and charts. While one student, 4%, chose to work backwards. An interesting strategy emerged during the share time following the problem solving activity.

Student 5 conveyed, “I counted by twos until I got to 40. Then I put them (twos) into groups of five, and came up with three groups. I multiplied $3 \times 5 = 15$, so I knew I had 15 animals. Then I circled two groups of twos, five times for the pigs because $4 \times 5 = 20$. That left me with ten twos. And 2×10 equals 20. Twenty pigs’ legs plus twenty chickens’ legs equals forty legs.”

Similar findings were verified through Student 23’s journal entries. After demonstrating great difficulty on four fraction problems, he successfully solved the following problem: Shirley has 18 coins. One sixth of the coins are quarters, one third of the coins are dimes, and one-half of the coins are nickels. What is the value of Shirley’s coins?

Student 23 requested counters to execute the problem and drew a diagram to demonstrate the results. Although the student responded, “I was very confused on this one,” he was able to execute the problem and develop a strategy for problem solution.

Explanation

In the category of explanation, students were evaluated on their written explanation and rationales that translated into words the steps of the solution process and provided justification for each step. Though important, length of the response, grammar, and syntax were not the critical elements of this dimension. These data were separated into one-week increments and analyzed. For each week, student's scores were calculated to determine a mean score. These data were used to categorize students in one of three performance ranges: above average, average, and below average. Mean scores ranging from 3.75 to 4.0 were considered above average, scores ranging from 3.0 to 3.5 were considered average, and scores of 2.75 and lower were considered below average. To determine the ranges in score, I divided each possible score by 4 to come up with a percentage. 3.75 to 4.0, the equivalent of 93% to 100% was considered above average according to our school grading scale. 3.0 to 3.5, the equivalent of 75% to 87% was considered average according to our school grading scale. 2.75 and below, the equivalent of 68% and lower was considered below average according to our school grading scale. Table 5 represents the average rubrics scores in explanation for the six-week research period.

Table 5: Summary of Results for Explanation

	Students with Above Average Scores	Percent of Class	Students with Average Scores	Percent of Class	Students with Below Average Scores	Percent of Class
Week 1	10	40%	6	24%	9	36%
Week 2	9	36%	7	28%	9	36%
Week 3	3	12%	7	28%	15	60%
Week 4	7	28%	5	20%	13	52%
Week 5	6	24%	4	16%	15	60%
Week 6	7	28%	2	8%	16	64%

Analysis of rubric scores indicated a decrease in students' explanations. The number of students with above average scores and average scores decreased over the six-week study. In addition, there was an increase in the number of students with below average scores.

One of the provisions required students to explain what was done and address why it was done. In addition, if a diagram was appropriate to the solution strategy, a complete explanation of all the elements in the diagram was required. Many students gave minimal explanation of the solution process, and often explained either what was done or why it was done. In reference to diagrams, many students incorporated diagrams into their solution strategies, yet failed to explain the elements of their diagrams.

Overall student growth was monitored and analyzed on a weekly basis. Students' responses to problems were graded in each of three categories: mathematical knowledge, strategic knowledge, and explanation. The three category scores were combined and each problem-solving exercise was given a holistic score. For each week, the student's holistic scores

were added together and a mean score was calculated. Table 6 represents the overall average rubrics scores for the six-week research period.

Table 6: Overall Average Rubric Scores

Student Number	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
1	3.5	3.3	2.3	3	3	2.8
2	3.6	3.9	3	2	3.3	2.2
3	3.7	3.8	2.6	4	3.9	3.9
4	3.9	4	3.3	3.3	3.2	3.2
5	3.3	3.8	2.6	3.2	2.1	1.7
6	2.3	2.8	2	3.2	1.7	1.2
7	1.9	2.5	1.4	2.8	1.7	1.2
8	3.3	4	3.5	3.6	3.4	3.2
9	3.8	3.4	3.1	2	2	1.8
10	2.8	2.5	1.8	3.1	.8	1
11	3	2.9	1.7	1.3	1.7	1.4
12	3	3.2	1.3	2	1.7	2
13	3.6	3.7	2.6	3.8	2.3	3.7
14	2.7	3.3	2.3	1.9	.8	1.8
15	2.2	3.4	2.3	2.5	1.7	2.9
16	3	3.2	3	3.9	2.2	1.5
17	4	4	3.5	3.8	3.8	3.8
18	3.7	3.4	2.8	2.7	2	2.2
19	4	2.4	2.3	3.2	1.8	2.7
20	3.8	3.9	3.7	4	3.6	3.3
21	3.6	3.8	3.3	3.7	3.3	2.8
22	2.6	2.8	1.6	1.2	2.6	1.2
23	3.5	3.8	2.4	3.1	2.9	3.7
24	3.8	3.8	3.6	3.3	3.2	3.6
25	3.4	3.4	3.7	4	3.7	3.3

These data were used to categorize students in one of three performance ranges: above average, average, and below average. Mean scores ranging from 3.6 to 4.0 were considered above average, scores ranging from 2.8 to 3.5 were considered average, and scores of 2.7 and lower were considered below average. To determine the ranges in score, I divided each possible score by 4 to come up with a percentage. 3.6 to 4.0, the equivalent of 90% to 100% was considered above average according to our school grading scale. 2.8 to 3.5, the equivalent of 70% to 87% was considered average according to our school grading scale. 2.7 and below, the equivalent of 67% and lower was considered below average according to our school grading scale. Table 7 represents the average holistic scores for the six-week research period.

Table 7: Average Holistic Rubric Scores

	Students with Above Average Score	Percent of Class	Students with Average Score	Percent of Class	Students with Below Average Score	Percent of Class
Week 1	11	44%	9	36%	5	20%
Week 2	11	44%	11	44%	3	12%
Week 3	3	12%	8	32%	14	64%
Week 4	8	32%	9	36%	8	32%
Week 5	4	16%	7	28%	14	64%
Week 6	5	20%	7	28%	12	48%

Analysis of the rubric scores indicated a general decline in student performance. The number of students with above average scores decreased over the six-week study. In addition,

there was an increase in the number of students with below average scores. Moreover, the amount of students with average scores stayed relatively the same.

Research Question #2: Students' Attitudes

Question 2: How does my practice of integrating writing with mathematics affect my fourth grade students' attitudes towards problem solving?

The first instrument used to measure my fourth-grade students' attitudes toward problem solving was the pre-and post- attitude inventory. The Attitude Inventory assesses students' willingness to engage in problem-solving activities, perseverance during the problem-solving process, and self-confidence with respect to problem solving.

The pre attitude survey was administered to 27 students in the class at the beginning of the research period. Student attrition affected the overall sample size, resulting in 25 participants, rather than the original 27.

Willingness

In the category of willingness to solve problems, there were six provisions. Three provisions were written to elicit a positive response and three of the provisions were written for a negative response. For each negatively worded item, a zero was assigned if marked "true" and one if marked "false." For each positively worded item, a zero was assigned if marked "false" and one if marked "true." An average score was determined by totaling the items and dividing by six. The resulting score represented each student's willingness to participate in problem solving as determined by the inventory.

Once the scores were recorded, a class average was determined by totaling the scores and dividing by 25. Eleven of the 25 students performed at or above the class average of 71%. Fourteen students fell below the class average of 71% in the area of willingness to solve problems.

The attitude inventory was administered again at the end of the research period. The average score for the pre-assessment was compared to the score of the post-assessment to determine any difference in willingness to solve problems. Table 8 presents the results of the pre and post inventory. Figure 1 presents the change in responses in the category of willingness to solve problems.

Table 8: Pre and Post Attitude Results for Willingness Raw Score Percentages (N = 6)

Student Number	Pre Attitude Responses	Post Attitude Responses	Change in Responses
1	100	100	0
2	50	50	0
3	83	83	0
4	100	100	0
5	66	50	-13
6	66	83	17
7	66	16	-50
8	33	100	67
9	50	83	33
10	66	33	-33
11	33	100	67
12	83	83	0
13	83	83	0
14	100	83	-17
15	33	33	0
16	100	83	-17
17	66	83	17
18	33	50	17
19	100	50	-50
20	100	100	0
21	66	66	0
22	50	33	-17
23	83	50	-33
24	66	0	-66
25	100	100	0

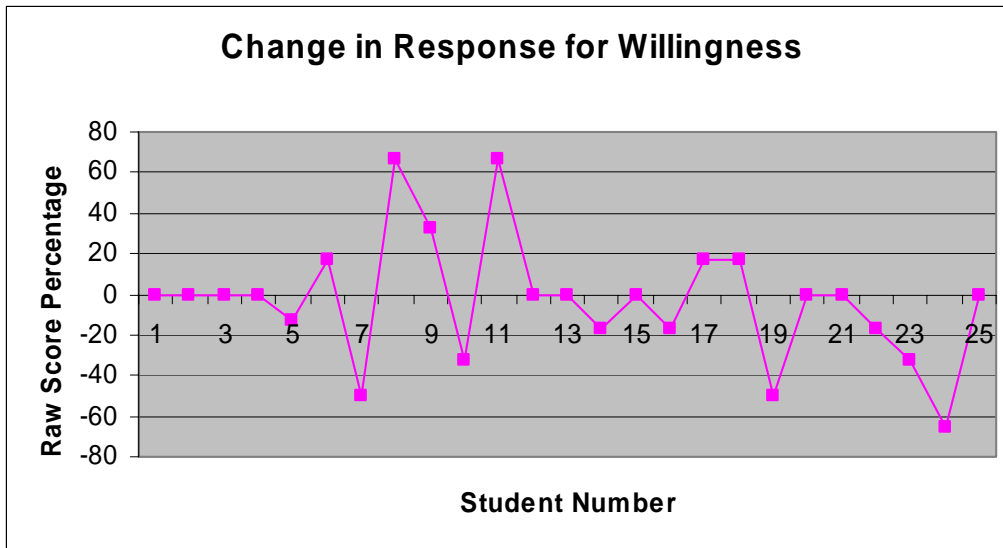


Figure 1: Change in Response for Willingness

Ten of the 25 students showed no change in willingness to participate in problem solving activities. Six of the 25 students showed an increase in willingness to participate in problem solving. Respectively, nine of the 25 students demonstrated a decreased interest in problem solving activities.

Field notes of teacher observations indicated that Students 5, 10, 14, and 22 often expressed difficulties during the problem solving activities. The aforementioned students frequently asked for help and were reluctant to start the activities without individual instruction. In addition, these students rarely conveyed their solution strategies during share time. Furthermore, Students 5, 10, and 14 had trouble finding more than one solution to combination problems and regularly were the first to finish.

At the beginning of the study, I requested that students write a “Mathematical Autobiography” with the purpose of discovering their attitudes toward mathematics. Student 5 wrote, “I don’t like math because it’s so compcate (complicated).” Student 10 expressed, “Sometimes I feel like crying because I’m afraid that people will laugh at me because I don’t know the problem.” Student 22 communicated, “I do not like math because sometimes questions are hard.” Finally, Student 14 suggested he enjoyed problem solving when he understood it.

Although Student 16 did fairly well on problem solving activities, anecdotal records indicate that he was repeatedly off-task and often needed redirection. Additionally, he often expressed disinterest by groaning at the inception of problem solving activities. A final indicator was communicated through his mathematical autobiography: “I don’t like math. Math does not like me.”

Surprisingly, teacher field notes pointed out that Students 7, 19, 23, and 24 seldom requested assistance and often spent a great deal of time working on their problems. Analysis of journal entries showed that Student 7 often made more than one attempt at finding a solution. However, in a letter writing activity, Student 7 expressed, “I hate some of the problem solving. I hate it because some of it is confusing to me and some of it doesn’t make sense.”

Student 19 often expressed an interest in problem solving and was eager to work with others. She often conveyed a positive attitude and was always willing to share strategies with the group. Although she did fairly well throughout the study, Student 19 indicated, “I don’t really like problem solving. The reason why is because some are really too hard for me.”

Student 24 also did well throughout the study and often expressed enthusiasm and a desire to work on problems. On many occasions he would pull in his fist and exclaim, “Yes!”

when problem solving activities were about to begin. This student expressed in his journal, “Math is not my favorite subject. It always turned out difficult so I would get confused.”

Perhaps the biggest shock was Student 23, who scored in the average range throughout the research period and often indicated that he thought his strategies were a big success. In his autobiography he revealed, “One thing I like about math is it is fun to do.” Additionally, through a letter writing activity, Student 23 indicated, “I like these problems...even if I get for instance a two or even a one I will just say that’s okay there’s always a next time.”

Although nine of the 25 students showed a decrease in willingness to solve problems, 16 of the 25, or 64% showed the same amount or an increased amount of willingness to participate in problem solving activities.

Perseverance

There were six provisions in the category of perseverance on the attitude inventory. Three of the provisions were written to elicit a positive response and three of the provisions were written for a negative response. For each negatively worded item, a zero was assigned if marked “true” and one if marked “false.” For each positively worded item, a zero was assigned if marked “false” and one if marked “true.” An average score was determined by totaling the items and dividing by six. The resulting score represented each student’s perseverance in problem solving as determined by the inventory.

The results of the inventory illustrate six of the 25 students scored 100% in the category of perseverance. Once the scores were recorded, a class average was determined by totaling the scores and dividing by 25. Twenty of the 25 students performed at or above the class average of

81%. Five students fell below the class average of 81% in the area of perseverance in problem solving.

The attitude inventory was administered again at the end of the research period. The average score for the pre-assessment was compared to the score of the post-assessment to determine any difference in perseverance in problem solving. Table 9 provides the results of the pre and post inventory. Figure 2 presents the change in responses in the category of Perseverance in problem solving.

Table 9: Pre and Post Attitude Results for Perseverance Raw Score Percentages (N = 6)

Student Number	Pre attitude responses	Post attitude responses	Change in responses
1	83	100	17
2	83	83	0
3	83	100	17
4	83	83	0
5	83	83	0
6	100	100	0
7	100	83	-17
8	100	100	0
9	83	83	0
10	100	33	-67
11	33	83	50
12	83	100	17
13	33	100	67
14	83	100	17
15	66	66	0
16	50	66	16
17	83	83	0
18	100	83	-17
19	83	83	0
20	66	66	0
21	83	100	17
22	83	16	-67
23	83	50	-33
24	100	33	-67
25	100	100	0

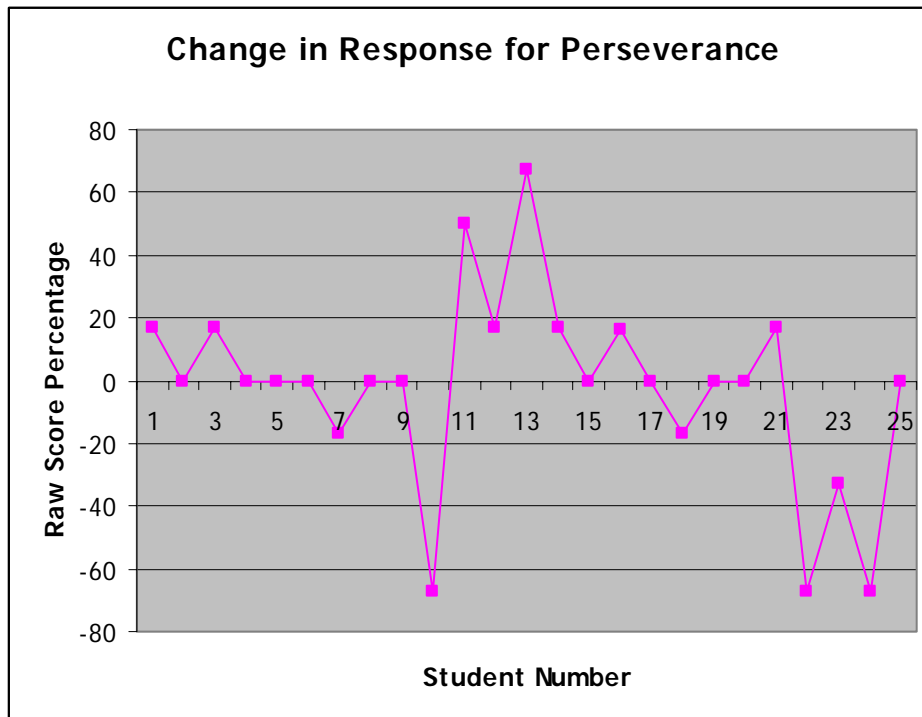


Figure 2: Change in Response for Perseverance

Eleven of the 25 students showed no change in perseverance in problem solving activities. Eight of the 25 students showed an increase in perseverance in problem solving. Respectively, six of the 25 students demonstrated a decreased determination in problem solving activities.

Students 7, 10, 18, 22, 23, and 24 exhibited a decrease in persistence while problem solving. Again, Students 10 and 22 expressed difficulty during the problem solving activities. They frequently requested assistance and regularly were the first to complete assignments.

In contrast, anecdotal records indicate that Students 7, 23, and 24 rarely asked for assistance and often showed enthusiasm while solving problems. These students also spent a fair

amount of time on problem solving activities. During cooperative activities, each of these children worked well with partners and willingly shared their solution strategies. In addition, Student 18 exhibited reluctance toward problem solving and indicated in her journal, “I think that problem solving is a little difficult because if you mess up a little then it messes up the hole thing.”

Furthermore, after sharing sessions, students were encouraged to rethink their strategies and rework their problems in order to raise their rubric scores. Students were permitted to work on their journals in their spare time and were allowed to take their notebooks home overnight. None of the students that showed a decrease in perseverance during problem solving took advantage of this option.

The post attitude inventory, in conjunction with anecdotal records, and student journals indicate an increase in perseverance during problem solving activities. While six of the 25 students showed a decrease in perseverance, 19 students, or 76% demonstrated the same amount or an increase in determination while participating in problem solving activities.

Self-Confidence

In the category of self-confidence in problem solving, there were eight provisions. Four of the provisions were written to elicit a positive response and four of the provisions were written for a negative response. For each negatively worded item, a zero was assigned if marked “true” and one if marked “false.” For each positively worded item, a zero was assigned if marked “false” and one if marked “true.” An average score was determined by totaling the items and

dividing by eight. The resulting score represented each student's self-confidence to participate in problem solving as determined by the inventory.

The results of the inventory illustrate four of the 25 students scored 100% in the category of perseverance. Once the scores were recorded, a class average was determined by totaling the scores and dividing by 25. Fifteen of the 25 students performed at or above the class average of 63%. Ten students fell below the class average of 63% in the area of self-confidence in problem solving.

The attitude inventory was administered again at the end of the research period. The average score for the pre-assessment was compared to the score of the post-assessment to determine any difference in self-confidence in problem solving. Table 10 presents the results of the pre and post inventory. Figure 3 presents the change in responses in the category of self-confidence in problem solving.

Table 10: Pre and Post Attitude Results for Self-Confidence Raw Score Percentages (N = 8)

Student Number	Pre Attitude Responses	Post Attitude Responses	Change in Responses
1	100	100	0
2	50	100	50
3	100	88	-12
4	100	100	0
5	63	38	-25
6	25	50	25
7	38	13	-25
8	100	100	0
9	75	75	0
10	38	25	-13
11	13	50	37
12	75	50	-25
13	38	50	12
14	63	63	0
15	88	100	12
16	88	63	-25
17	88	100	12
18	25	50	25
19	38	75	37
20	88	75	-13
21	63	100	37
22	63	50	-13
23	50	50	0
24	25	13	-12
25	88	88	0

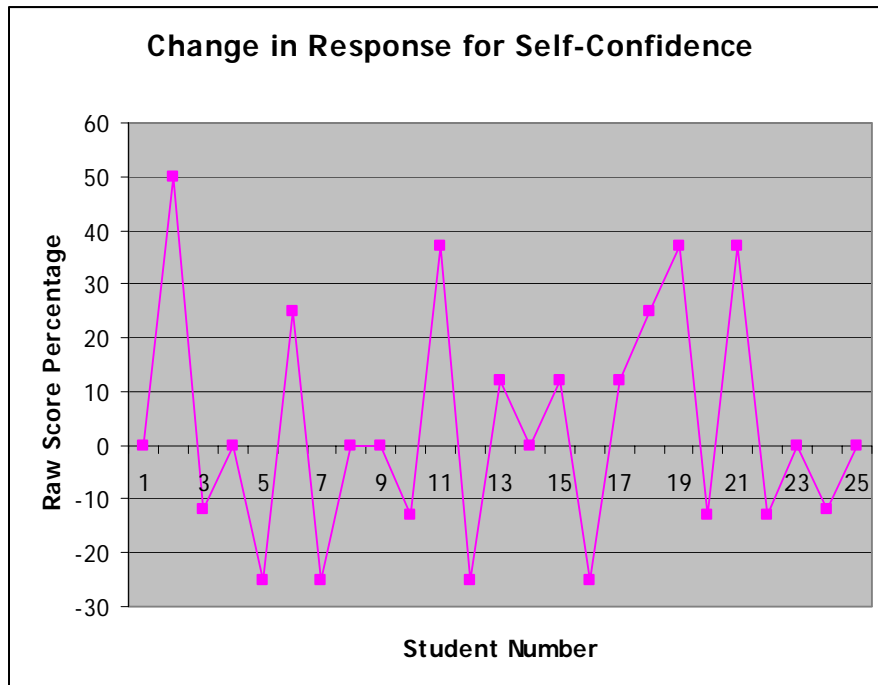


Figure 3: Change in Response for Self-Confidence

Seven of the 25 students showed no change in self-confidence toward problem solving activities. Nine of the 25 students showed an increase in self-confidence toward problem solving activities. Respectively, nine of the 25 students demonstrated a decrease in self-confidence toward problem solving activities.

Several indicators on the attitude inventory suggested that students needed help while solving problems. During the research period, students often sought assistance from the teacher and each other. Collaboration was encouraged in the classroom, yet it was negatively valued on the inventory. Recognizing the need for assistance and acting on it was highly valued in the classroom. In my opinion, it should not be considered as a slight to one's self-confidence.

The post attitude inventory, in conjunction with anecdotal records, and student journals indicate an increase in self-confidence during problem solving activities. While nine of the 25 students showed a decrease in perseverance, 16 students, or 64% demonstrated the same amount or an increase in self-confidence while participating in problem solving activities.

Research Question #3: Relationships Between Attitudes and Performance

Question 3: Is there a relationship between students' attitudes in problem solving and their achievement in problem solving?

As part of my research, I wanted to determine whether students' attitudes in problem solving were related to their achievement. For instance, do students with average to above average attitudes also demonstrate average to above average performance on problem solving activities? To triangulate my findings, I consulted anecdotal records of teacher field notes, attitude inventories, and problem solving rubrics of student journal entries.

In order to compare scores, I needed to obtain an overall average of student performance for each participant. These data were used to categorize students in one of three performance ranges: above average, average, and below average. Mean scores ranging from 3.6 to 4.0 were considered above average, scores ranging from 2.8 to 3.5 were considered average, and scores below 2.8 were considered below average. The categorized data provide the following: three (3) students with above average scores (12% of the class), twelve (12) students with average scores (48% of the class), and ten (10) students with below average scores (40% of the class).

Additionally, it was necessary to acquire an overall average of student attitude for each participant. Again, the Attitude Inventory Assessment was scored using guidelines from the

NCTM (1987) *How to Evaluate Progress in Problem Solving*. Items were worded to reveal positive or negative feelings. For each negatively worded item, a zero was assigned if marked “true” and one if marked “false.” For each positively worded item, a zero was assigned if marked “false” and one if marked “true.” Inventories were totaled and a mean score was calculated. These data were used to place students in one of three ranges of attitude: above average, average, and below average. Mean scores ranging from 90 to 100 % were considered above average, scores ranging from 70 to 89% were considered average, and scores of 69% and lower were considered below average. The categorized data provide the following: eight (8) students with above average scores (32% of the class), nine (9) students with average scores (36% of the class), and eight (8) students with below average scores (32% of the class).

Once the averages were obtained for each student, I placed them in a spreadsheet and coded each student according to their performance and attitude score. AA represented above average scores, A signified average scores, and BA symbolized below average scores. Table 11 compares student performance and student attitudes.

Table 11: Comparison of Student Performance and Student Attitudes

Student Number	Performance	Attitude
1	A	AA
2	A	A
3	AA	AA
4	A	AA
5	BA	BA
6	BA	BA
7	BA	BA
8	A	AA
9	BA	A
10	BA	BA
11	BA	A
12	BA	A
13	A	A
14	BA	A
15	BA	A
16	A	A
17	AA	AA
18	A	BA
19	A	A
20	AA	AA
21	A	AA
22	BA	BA
23	A	BA
24	A	BA
25	A	AA

Analysis of overall student performance and attitudes indicated that three of the 25 participants, 12% scored above average on both their performance rubrics and attitude inventories. In addition, nine of the participants, 36% scored in the average range on their performance rubrics and were categorized with average to above average attitudes. Furthermore,

five students, 20% placed in the below average range on both their performance rubrics and attitude inventories.

In contrast, eight participants, 32% placed in varying categories on their performance rubrics and attitude inventories. Students 9, 11, 12, 14, and 15 demonstrated positive scores on their attitude inventories, yet performed below average on their problem solving activities. Such results are promising because these low achieving students maintained a positive attitude toward problem solving despite their below average rubric scores.

On the contrary, Students 18, 23, and 24 had discouraging results. Although they maintained average scores on their problem solving performance rubrics, their attitudes fell in the below average range. Examination of anecdotal records and student journals revealed conflicting data.

Examination of Student 23's journal divulged that he maintained correspondence throughout the study period. He often noted when problems were easy and indicated when problems were a "big success." Anecdotal records disclosed that he expressed enthusiasm toward the culminating activity, which involved student-authored problems and was very eager to share strategies during discussion periods.

Further examination of student journals revealed that Student 24 maintained correspondence throughout the study period as well. He demonstrated a willingness to correct problems and often noted problems he especially liked. Teacher observations revealed a positive attitude during problem solving activities and an enthusiasm for sharing strategies.

Finally, investigation of student journals revealed that Student 18 also maintained correspondence throughout. In one communication she revealed, "It (problem solving) can be fun like the resterant (restaurant) problem. Because when I figured it out it was fun to find out."

In addition, she wrote, “The other reason the resterent (restaurant) problem was fun was because when the anwer (answer) is cool and things you think nobody would figure out.” In her mathematical autobiography, Student 18 indicated, “My teacher in third grade inceroged (encouraged) me to like math and my teacher this year makes me like math even more.” In contrast to Students 23 and 24, Student 18 was apprehensive to share strategies during discussion sessions. Further analysis of her attitude inventory revealed that although she demonstrated an increase in score in the categories of willingness and self-confidence, her final scores fell well below the class average.

As a result, 17 students, 68% had corresponding scores on their overall averages of their performance and attitudes. Generally, students with average to above average scores on performance tasks demonstrated average to above average scores on their attitude inventories. Respectively, students with below average scores on performance tasks exhibited below average scores on their attitude inventories.

Summary

Based on the triangulation of the sources of data, I found that, although minimal, the overall increase in students’ mathematical knowledge was demonstrated through mathematical discourse during problem solving activities and strategy share sessions. Students also demonstrated that they were able to incorporate and apply new concepts into their solution strategies and student authored story problems.

My analysis of the data from all three instruments also revealed that strategic knowledge was demonstrated through the variety of strategies exhibited in student journals and shared in

discussions. Students often utilized manipulatives to aid in their solution strategies and frequently drew diagrams and charts. Students also employed strategies they learned from share sessions into problems of similar nature.

Moreover, examination of the data indicated an overall decrease in students' explanations. Although students were able to share their solution steps and strategies verbally, their written explanations were often minimal and excluded many important elements. Frequently, students neglected to address both what was done and why. In addition, they often forgot to explain all of the elements in their diagrams.

In this study, all three data-collection instruments demonstrated students' positive attitudes toward problem solving. An overall average indicated that 68% of students maintained or achieved average to above average attitudes, while only 32% of students possessed below average attitudes. Anecdotal records revealed enthusiasm during problem solving activities and share sessions. Journal evaluation suggested that students enjoyed problem solving and liked being challenged.

Final evaluation of the data sources illustrated a relationship between student performance and attitude. Sixty-eight percent of the participants had corresponding scores on the overall averages of their performance and attitudes. Of the 25 participants, 48% illustrated average to above average performance and attitude scores.

Chapter Five will conclude my study on the effects of writing activities on students' attitudes and achievement in problem solving. In Chapter Five, I will review current research as it relates to my findings and offer recommendations for future research in the area of writing activities and mathematics in a fourth grade classroom.

CHAPTER FIVE: SUMMARY AND RECOMMENDATIONS

This study was conducted to determine the effects of writing activities on students' attitudes and achievement in problem solving. A goal of the study was to discover improvements in student performance and student attitudes on problem solving activities and the relationship between attitudes and performance in problem solving. The driving force of this study is the recent demand on our students to explain their mathematical processes in most of standardized testing. The Florida Comprehensive Assessment Test (FCAT) requires students to respond to problems using reliable methods and provide clear and complete justifications of their problem solving procedures. This chapter will elaborate on my conclusions as they relate to current research and offer recommendations for future research in the area of writing activities and mathematics in a fourth grade classroom.

Summary

In this study, students demonstrated an overall increase in mathematical performance, measured in the analysis of early and recent writing samples and teacher field notes. In addition, all three data collection instruments showed an overall increase in students' attitudes toward problems solving. Concurrently, a comprehensive examination of the pre and post attitude inventories indicated that 68% of students maintained or achieved average to above average attitudes. Furthermore, analysis of the data revealed an existing relationship between students' performance and attitude as they relate to problem solving.

Conclusions

Based on the patterns found within the data, I concluded that students demonstrated an overall increase in mathematical performance when writing activities were integrated into the mathematics curriculum. Positive results in student performance resulted from integrating writing activities into my mathematics teaching practices.

Three questions were answered during this study:

Question 1: How does my practice of integrating writing with mathematics affect my fourth grade students' achievement in problem solving?

The results of this study and the literature review led me to conclude that writing activities positively affected my fourth grade students' general mathematics performance. However, the research on the effect of writing on the affective learning outcomes of mathematics is limited at the elementary level. At the junior high level, Clarke et al. (1993) reported a positive relationship between journal writing and students' perception of mathematics. Bell and Bell (1985) reported a positive effect of writing on mathematical problem solving at the senior high school level.

Analysis of rubric scores indicated little growth in students' achievement in the category of mathematical knowledge. A possible cause is that as the study went on, problems became increasingly difficult. Problems addressed new concepts in which students had little background knowledge. Problems involving fractions and algebraic thinking were especially complex. In addition, multi-step problems proved to be challenging for many students.

Anecdotal records and analysis of student journal entries provided opposing information. Prior to the study, a majority of students demonstrated weak multiplication skills. Over the

course of the study, new multiplication algorithms were introduced. Journal entries and field notes indicated that most of the students were able to incorporate these new concepts into their solutions.

Over the course of the study, students used appropriate mathematical terminology in their journal entries and share sessions. Field notes revealed an increase in mathematical discourse among students. Through discourse, students acquired knowledge of word-problems and transferred this knowledge to problem solving. According to Rudnitsky et al. (1995), “Through writing, students can experience the role of language in the production of knowledge as well as the presentation of knowledge, and they can themselves become the producers of that knowledge. This corresponds to a constructivist view whereby the most meaningful and memorable learning is that constructed and “owned” by learners themselves” (p. 469).

In addition, students were able to correctly execute algorithms during the problem solving process. Through student-authored problems, participants were able to demonstrate knowledge of mathematical principles and concepts. Accordingly, students demonstrated mathematical knowledge on many different types of problems.

As part of their study, Rudnitsky et al. (1995) incorporated several lessons, which engaged students in the creation of mathematical stories and story problems. The researchers maintain, “To write a comprehensible problem, a student presumably must understand the concept underlying the problem” (p. 470). This valuable method enabled students to demonstrate understanding of the concept underlying the self-created problems.

Although rubric scores indicated minimal growth in strategic knowledge, students provided a variety of strategies for finding solutions during sharing sessions. I think the length of the study influenced students’ limited growth. In addition, there was no direct instruction

provided for problem solving strategies. Through a constructivist framework, I hoped that students would construct their own knowledge and develop their own solutions for solving problems. I had also hoped that they would learn from each other through collaborative experiences and shared discussions.

Emphasis was taken away from formal correctness and finished products, and placed on the processes used toward finding solutions. Students realized that there were several ways to solve problems and demonstrated this knowledge by applying various strategies in their solution steps. In their study, Borasi and Rose (1989) discovered how students solved a problem or approached the study of a topic. The researchers found students can “be encouraged to become introspective of how they do and learn mathematics, and consequently, be brought to identify more general heuristics to solve mathematics problems as well as to realize the possibility of alternative approaches to the same learning task” (p. 356). Furthermore, “An increased awareness of the process of doing mathematics seems especially important for the students’ success in mathematics” (Borasi & Rose, 1989, p. 356).

The examination of my practice integrating writing activities with problem solving upheld the constructivist principles of building on existing knowledge to actively construct new knowledge through experiences and interactions. “Students come to mathematics class having a variety of real-world experiences on which to continue the construction of their knowledge of mathematics. The construction of knowledge requires active engagement in thought-provoking activities. Because writing leads people to think, improved mastery of mathematics concepts and skills is possible if students are asked to write about their understanding” (Miller, 1991, p. 517).

Clarke et al. (1993) observed students initiating questions about what they were doing, and demonstrating increasing confidence in using their own words to link ideas. They were able

to make suggestions about possible ways to solve problems, even if these approaches did not prove to be successful. Through their writing, they showed they were actively constructing mathematics.

Analysis of rubric scores indicated a decrease in students' explanations. One of the provisions required students to explain what was done and address why it was done. In addition, if a diagram was appropriate to the solution strategy, a complete explanation of all the elements in the diagram was required. Many students gave minimal explanation of the solution process, and often explained either what was done or why it was done. In reference to diagrams, many students incorporated diagrams into their solution strategies, yet failed to explain the elements of their diagrams.

I believe the lack of elaboration could be attributed to the emphasis placed on writing in fourth grade. Much time was dedicated to writing exercises and students regularly participated in school wide writing prompts. Perhaps all of the preparation for the FCAT Florida Writes influenced their desire to expand upon their solutions.

Question 2: How does my practice of integrating writing with mathematics affect my fourth grade students' attitudes towards problem solving?

The results of this study and the literature review led me to conclude that writing activities positively affected my fourth grade students' attitudes toward problem solving. Attitudes were measured in three categories: students' willingness to engage in problem-solving activities, perseverance during the problem-solving process, and self-confidence with respect to problem solving.

Examination of pre and post attitude inventories revealed 68% of students maintained or achieved positive attitudes in the area of willingness to engage in problem-solving activities. Inventory items focused on students' enthusiasm toward problem solving and their readiness to attempt complex problems. In addition, 76% of students maintained or achieved positive attitudes in the category of perseverance during the problem-solving process. Items focused on students' persistence and willingness to continue until the solution process is complete. Furthermore, 64% of students maintained or achieved positive attitudes in the section regarding self-confidence. Students responded to judgments about their problem solving abilities. Items focused on being a good problem solver, the ability to solve difficult problems, and comparing their abilities to other students in the group. Final examination of the post attitude inventory revealed that 68% of participants maintained or achieved average to above attitudes regarding problem solving.

Miller and England (1989) reported a positive effect of writing on the attitudes of algebra students toward mathematics.

“The attitudes of the students and the teachers toward each other and about the teaching and learning of algebra improved over time. Students' comments indicated that they enjoyed the opportunity to express themselves. They suggested that, because of the writing, the teacher expressed concern about the problems they were having and viewed the writings as a means through which the teacher could find out how to help them” (p. 310).

Examination of anecdotal records in this study indicated a motivating factor for students' writing was the ongoing journal dialogue between participant and observer. As students came to expect regular feedback regarding their journal entries, a rapport developed between the students

and the teacher. Through dialogue, students were able to express difficulty in the solution process in a risk-free, caring environment. Ongoing dialogue permitted students to comment about problems they enjoyed and allowed them to communicate their thoughts and feelings about problem solving. Because of their confidential nature, writing activities took the focus away from individual students, allowing them to write without drawing attention from their peers. Miller (1991) states, “given the opportunity to write about their understanding, or lack of understanding, of mathematics, students who will not ask questions in class may express their confusion privately in writing” (p. 518). In addition, “The students see the teacher adjusting his or her schedule to accommodate their needs, and everyone feels better about addressing their lack of understanding” (Miller, 1991, p. 519).

Question 3: Is there a relationship between students’ attitudes in problem solving and their achievement in problem solving?

Triangulation of the data sources illustrated a relationship between students’ performance and attitudes. A comparison of the post attitude inventory and an average of rubric scores indicated 68% percent of the participants had corresponding scores on the overall averages of their performance and attitudes. As well, journal entries provided an avenue of communication for students to express their thoughts and feelings about the problem solving process. In addition to their visible reactions during the problem solving process and share sessions, attitudes were measured through journal responses. Writing activities allowed students to convey enthusiasm for their successful procedures, as well as frustration for the problems they found challenging and difficult. Following their study, Borasi and Rose (1989) found,

“The journals can also positively influence the student-teacher interaction and classroom atmosphere; when students and teachers freely communicate and see

each other as caring human beings, the classroom can turn into a more pleasant environment where all members become partners in learning” (p. 363)

Discussion and Recommendations

Writing activities play an important role in the teaching and learning of problem solving. Incorporating writing into the mathematics classroom provides daily opportunities for communication between teachers and students, and provides an avenue for teachers to evaluate students’ conceptual development. Borasi and Rose (1989) posit,

“When students write entries and the teacher reads and responds to them, a new mode of communication is created in the classroom – a private dialogue between the teacher and each student. Not only can teachers and students learn more about each other and interact more personally in this way, but a different rapport between them can be established, with positive benefits for both parties” (p. 360).

Through this study, I was able to establish special relationships with my students and gain privileged information about their attitudes toward problem solving. In turn, I gained insight about each child, as a person and a learner. While journals permitted me to address the individual needs of each student, they also provided a record of student growth throughout the study period.

Furthermore, as students began to take risks and share their ideas with peers, a collaborative culture emerged in the classroom. Consequently, children sought the advice of their classmates and learned from one another. The National Council of Teachers of Mathematics

(NCTM, 2000) indicate, “Student who have opportunities, encouragement, and support for speaking, writing, reading, and listening in mathematics classes reap dual benefits: they communicate to learn mathematics, and the learn to communicate mathematically” (p. 59).

While integrating writing and problem solving is an effective teaching practice, it is by no means a panacea. It is an alternative instructional vehicle with many associated benefits. Journal entries impart a window to students’ thinking, yet integrating writing into the mathematics classroom is an arduous task. Assessing and responding to student journal entries is very time consuming. However, it is time well spent. Teachers interested in engaging in an action research of this nature must be willing to allocate extensive amounts of time for evaluation and communication.

Because findings in one fourth-grade classroom cannot be generalized to all fourth graders, a larger population is recommended for further research. Another recommendation I have pertaining to this action research is to extend the study over a longer period. Due to time constraints and missed days resulting from three hurricanes, I was only able to observe my students over the course of six weeks. Extending the study period over a longer time might address some of the study’s limitations. Journal entries could be written three times a week, instead of everyday, which would permit the observer more time in between sessions to evaluate and reflect upon students’ responses.

I would also recommend that the researcher join the students in writing activities. Modeling writing and sharing it with students will make the expectations clear. As they share their perspectives as learners, the teacher can impart the point of view as an educator of mathematics. Sharing solutions, thoughts and feelings about the mathematics will foster a caring environment in which everyone learns.

Another suggestion I have is to conduct focus groups and interviews with the participants. Although structured interviews take a great deal of time, this method allows the evaluator the opportunity to ask probing questions and allows for responses more elaborate in nature. This technique permits students to give detailed responses regarding what they are thinking and doing and provides “insight into a student’s thinking processes that are not usually apparent from written work” (Charles et al., 1988).

Last of all, I would adapt the rubric to make it more understandable for students. In turn, I would incorporate self-evaluation as part of the study. By assessing their responses, and those of their peers, students would gain a working knowledge of the rubric. Focus would be taken away from the researcher’s evaluations, and students would gain a sense of ownership and responsibility.

As a result of this study, I have witnessed the benefits of integrating writing activities and problem solving. As a teacher of mathematics, I will continue to support a collaborative culture in the classroom and provide opportunities for students to communicate their thoughts and understandings in all areas of the mathematics curriculum. Communicating ideas and connecting them to what is already known are key features of students’ writings. Through written communication, students provide a window to their understanding of mathematical concepts. Furthermore, writing activities assist students in seeing themselves as active agents in the construction of mathematical knowledge and foster a sense of ownership and responsibility for one’s own thoughts. Once written, their thoughts and ideas become reflective tools that can be analyzed, corrected, and expanded upon.

APPENDIX A: PROBLEM SOLVING RUBRIC

SCORE LEVEL	MATHEMATICAL KNOWLEDGE:	STRATEGIC KNOWLEDGE:	EXPLANATION:
4	Complete understanding of mathematical concepts and principles; Appropriate terminology Algorithms complete and correct	Identifies important elements; shows complete understanding of relationships among elements; Reflects appropriate strategy for solving problem.Solution process is nearly complete.	Complete written explanation; explains what is done and why. If a diagram, a complete explanation of all the elements is evident.
3	Nearly complete understanding of concepts and principles; nearly correct terminology; Executes algorithms completely; computations generally correct but may contain errors	Identifies most important elements; general understanding of relationship among elements; appropriate strategy for solving the problem; solution process nearly complete	Nearly complete explanation of solution process, or explains what was done and begins to address why it was done May include a diagram with most of the elements explained.
2	Shows some understanding of the mathematical concepts and principles May contain major computational errors	Identifies some important elements, but shows only limited understanding of the relationship among them	Some written explanation of the solution process; explains what was done, or why it was done; explanation vague or difficult to interpret. May include a diagram with some of the elements explained
1	Limited to no understanding of concepts and principles; may misuse or fail to use mathematical terms; may contain major computational errors	Fails to identify important elements or places emphasis on unimportant elements; may reflect inappropriate or inconsistent strategy; gives minimal evidence of solution process; process may be difficult to identify	Minimal written explanation; may fail to explain what was done and why it was done; explanation does not match presented solution process; may include minimal discussion of elements in diagram;explanation of significant element is unclear.

Adapted with permission from *Scoring rubrics in the classroom: Using performance criteria for assessing and improving student performance*, copyright 2001, by the Illinois State Board of Education.

APPENDIX B: ATTITUDE INVENTORY

Name: _____

Date: _____

Pretend you have been given some math story problems to solve. Mark true or false depending on how the statement describes you. There are no right or wrong answers.

1. I will put down any answer just to finish a problem. _____
2. It is no fun to try to solve problems. _____
3. I will try almost any problem. _____
4. When I do not get the right answer right away I give up. _____
5. I like to try hard problems. _____
6. My ideas about how to solve problems are not as good as other students' ideas. _____
7. I can only do problems everyone else can do. _____
8. I will not stop working on a problem until I get an answer. _____
9. I am sure I can solve most problems. _____
10. I will work a long time on a problem. _____
11. I am better than many students at solving problems. _____
12. I need someone to help me work on problems. _____
13. I can solve most hard problems. _____
14. There are some problems I will just not try. _____
15. I do not like to try problems that are hard to understand. _____
16. I will keep working on a problem until I get it right. _____
17. I like to try to solve problems. _____
18. I give up on problems right away. _____
19. Most problems are too hard for me to solve. _____
20. I am a good problem solver. _____

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APPENDIX C: INSTITUTIONAL REVIEW BOARD APPROVAL



Office of Research

July 12, 2004

Ms. Kelly Culbert
6336 Raleigh Street #1212
Orlando, FL

Dear Ms. Culbert:

With reference to your protocol entitled, "Writing as a Constructivist Approach to Problem Solving," I am enclosing for your records the approved, expedited document of the UCFIRB Form you had submitted to our office.

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur. Further, should there be a need to extend this protocol, a renewal form must be submitted for approval at least one month prior to the anniversary date of the most recent approval and is the responsibility of the investigator (UCF).

Should you have any questions, please do not hesitate to call me at 823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

A handwritten signature in cursive script that reads "Barbara Ward".

Barbara Ward, CIM
Institutional Review Board (IRB)

Copies: Dr. Enrique Ortiz, Department of Education
IRB File

APPENDIX D: PRINCIPAL PERMISSION LETTER

June 21, 2004

Dear IRB Coordinator,

Ms. Kelly Culbert has notified me of the nature of her action research to take place from August, 2004 to February, 2005. It is my understanding that her action research will investigate the effects of journal writing on student achievement and attitudes in problem solving.

Ms. Culbert has made it clear that student participation or nonparticipation in this study will not affect student progress, and there are no anticipated risks to students during the proposed action research. Upon receiving the required signed parental consent form and student assent, I authorize Kelly Culbert to conduct the proposed study.

Sincerely,

A handwritten signature in cursive script that reads "Margaret Osteen".

Dr. Margaret Osteen
Principal

APPENDIX E: PARENTAL CONSENT FORM

August 6, 2004

Dear Parent/Guardian,

I am a graduate student at the University of Central Florida under the supervision of faculty member, Dr. Enrique Ortiz, conducting research on the effects of journal writing on student achievement and attitudes in problem solving. The purpose of this study is to compare students' problem solving skills and attitudes before and after using problem-solving journals as a part of daily mathematics instruction.

The action research that I will be conducting consists of a pre and post Attitude Inventory, student journals, and interviews. Students will be introduced to the fourth grade mathematics standards through problem solving and problem posing exercises. Students will keep problem solving journals that will contain their daily problem solving efforts as well as reflections written about the problem solving experience. I will be collecting attitude data using the pre and post Attitude Inventory, journal responses, and interviews. I will be assessing student problem solving achievement using an analytical rubric.

With your permission, your child will be videotaped and tape-recorded during various instructional periods. The video will be accessible only to the researcher for data collection and verification purposes. All video and audiotapes will be destroyed when the research is complete. Although children will be asked to write their names on their work, their identity will be kept confidential to the extent provided by law. Pseudonyms or coding will be used in all research reports. Participation or nonparticipation in this study will not affect your child's grades.

You and your child have the right to withdraw consent for your child's participation at any time without consequence. There are no known risks or immediate benefits to the participants. No compensation is offered for participation. If you have any questions about this research project, please contact me at (407) or my faculty supervisor, Dr. Enrique Ortiz at (407) . Questions or concerns about research participants' rights may be directed to the UCFIRB office, University of Central Florida Office of Research, Orlando Tech Center, 12443 Research Parkway, Suite 207, Orlando, FL 32826. The phone number is (407) 823-2901.

If you understand the research procedures outlined above and consent to your child's participation, please sign and return one copy of the parental consent form attached.

Sincerely,

Ms. Kelly Culbert

Parental Consent Form

_____ I have read the procedure described in the letter from Ms. Culbert dated August 6, 2004.

_____ I voluntarily give consent for my child, _____, to participate in Ms. Kelly Culbert's study of the effects of journal writing on student achievement and attitudes in problem solving.

_____ I would like to receive a copy of the procedure description.

_____ I would not like to receive a copy of the procedure description.

_____/_____
Parent/Guardian Date

_____/_____
Parent/Guardian Date

APPENDIX F: CHILD ASSENT SCRIPT

Child Assent Script

Good morning, class. Like you, I am also a student. I attend the University of Central Florida where I am currently working on my masters in education. As part of my program, I will be conducting a research project, which focuses on journal writing and problem solving. While in my class, you will keep a journal to help show how much you have learned. In addition, I will be videotaping and tape-recording some of our conversations about mathematics. You may stop at any time and you will not have to answer any questions you do not want to answer. Would you like to do this?

**APPENDIX G: PERMISSION TO USE THE NCTM ATTITUDE
INVENTORY**

Culbert, Kelly A.

From: Permissions [Permissions@nctm.org] **Sent:** Fri 11/12/2004 2:38 PM
To: Culbert, Kelly A.
Cc:
Subject: Re: permission request
Attachments:

Dear Ms. Culbert:

This e-mail constitutes our permission for you to use "Attitude Inventory from How to Evaluate Progress in Problem Solving in the form of pre- and post-test inventory for your masters research with your fourth class. Please use the following credit line to accompany this material:

Reprinted with permission from [name of book or journal], copyright [year] by the National Council of Mathematics. All rights reserved.

Thank you for your request.

Sincerely,
Denise Baxter
Asst. Permissions Editor
National Council of Teachers of Mathematics
1906 Association Drive
Reston, VA 20191-1502
Email: Permissions@nctm.org
Phone (703) 620-9840 ext. 2157
Fax (703) 476-2970

>>> "Culbert, Kelly A." <CulberK@ocps.k12.fl.us> 11/09/04 07:20PM >>>
To whom it may concern:

I am writing to seek permission to use the Attitude Inventory from your published text "How to Evaluate Progress in Problem Solving." I am a graduate student at the University of Central Florida conducting action research in my own classroom. The published Attitude Inventory Items found on page 27 was an asset to my research, the effects of journal writing on students' attitudes and achievement in problem solving.

I would use the Attitude Inventory items in the form of pre- and post-test inventory for my fourth grade students.

Respectfully,

Kelly Culbert
Princeton Elementary
Orlando, FL

culberk@ocps.net

<http://owa.ocps.net/exchange/CulberK/Inbox/Re:%20permission%20request.EML?Cmd=or>

APPENDIX H: DAILY PROBLEMS

1. In Panacola's Restaurant, a circular table seats 4 people. A rectangular table seats 6 people. There are 18 people waiting to be seated. How can it be done?
2. There are 5 students in Mrs. Martin's class who wish to ride on a "bicycle built for two." How many rides must they take so that each person rides with each other person just one time?
3. Arthur is making lunch. He makes sandwiches with white bread or rye bread. He uses either cheese, jelly, or lunchmeat. How many different sandwiches can he make?
4. Nina asked her dad how old he was. He told her, "If I add 10 to my age and double the result, I will get 84." How old is Nina's dad?
5. A farmer has 15 animals, some pigs and some chickens. Together, they have a total of 40 legs. How many pigs and how many chickens does the farmer have?
6. Lucy has a dog, a parrot, a goldfish, and a Siamese cat. Their names are Lou, Dotty, Rover, and Sam. The parrot talks to Rover and Dotty. Sam cannot walk nor fly. Rover runs away from the dog. What is the name of each of Lucy's pets?
7. Start with 99. You can add or subtract 5, 9, and 13. You must use each number at least once. Your goal is to hit 100.
8. A digital clock shows either three or four digits. At what time do the digits have the greatest sum?
9. November 8 is on Wednesday. Gary's birthday is in November. This year his birthday is on a weekend. The date has two digits. You say the date when you count by twos. The sum of the digits is 8. What is the day and date of Gary's birthday?
10. At Henry's Restaurant, a customer gets a free lunch after paying for six. Caroline ate lunch at Henry's 50 times last year. How many of those 50 lunches were free?

11. If you must use two quarters and a total of 8, 9, or 10 coins, how many different combinations of coins can be used to make a dollar?
12. It takes Jerry 12 steps to go across the classroom. It takes Mary 16 steps. If Jerry has taken nine steps, how many steps has Mary taken?
13. Sam, Nancy, Becky and Jimmy all eat lunch in the same restaurant. All of them are eating there today and Sam eats there every day. Nancy eats there every other day, Becky eats there every third day and Jimmy eats there every fourth day. The next time they are all together they will celebrate. How many days before they will all be together again?
14. List the possible pizza combinations you can pick that have only one topping. Size: small, medium, large; Crust: thick, thin, pan; Toppings: cheese, pepperoni, hamburger.
15. Roy bought a ball that bounces exactly half the height from which it is dropped. He drops it from the top of a building that is 30 meters tall. How high will the ball bounce after its fourth bounce?
16. If you write the numbers from 1 to 99, how many times would you write the digit 1?
17. In a fourth-grade class, two out of four students bring their lunches to school. There are 28 students in the class. How many students in the class bring their lunches to school?
18. Tonya is making bracelets for each of 8 girls coming to her party. Each bracelet will be braided with 4 purple, 3 yellow, 2 green, and 3 blue strings. Each string costs 10 cents. It takes Tonya about 20 minutes to braid each bracelet. How much will the string cost? How long will it take to make all the bracelets?
19. The sum of 3 consecutive numbers is 276. What are the numbers?
20. Sue's group of friends is going into the 5th grade. Their homerooms will be rooms 12, 14, or 16. All of her friends but 4 are going to room 12. All but 4 are going to room 14, and all but 4 are going to room 16. Not counting Sue, how many children are in her group of friends?

21. Together, 6 boys and 12 girls weigh 1050 pounds. The boys all weigh the same, x pounds. Each girl weighs 55 pounds. What is the weight of one boy?
22. Shirley has 18 coins. One sixth of the coins are quarters, one third of the coins are dimes, and one-half of the coins are nickels. What is the value of Shirley's coins?
23. Sam and Suzie are twins. Sam has as many brothers as he has sisters. Suzie has at least 1 sister, and twice as many brothers as sisters. How many kids are in the family altogether?
24. Maria needed some magazine pictures for a social studies project. She cut out pages 20, 21, 47, 48, and 104. How many sheets of paper did she remove from the magazine?
25. The news costs \$.35 at the newsstand and is published Monday thru Friday. You can also buy a 4-week subscription for \$4.75. If you bought a 4-week subscription, how much would you save over buying it for four weeks at the daily rate?
26. You can roll two dice at a time, a white one and a red one. There are 36 different ways for the "up faces" to land. How many ways will give a sum of 7 on two faces?
27. A tropical storm passed through the town. It began to rain Monday morning at 8:45 a.m. and did not stop until the next day at 2:30 p.m. How long did it rain?

**APPENDIX I: PERMISSION TO USE THE PROBLEM SOLVING
RUBRIC**

Culbert, Kelly A.

From: CRAIG JOHN C [JCRAIG@isbe.net]

Sent: Wed 6/30/2004 4:04 PM

To: Culbert, Kelly A.

Cc:

Subject: RE: request for permission

Attachments:

Such permission is granted.

-----Original Message-----

From: Culbert, Kelly A. [mailto:CulberK@ocps.k12.fl.us]

Sent: Monday, June 28, 2004 6:27 PM

To: CRAIG JOHN C

Subject: request for permission

Dear Dr. Craig,

I am writing to seek permission to use the Mathematics Scoring Rubric from the Illinois Standards Achievement Test: Sample Mathematics Materials 2000 (p. 59). I am a graduate student at the University of Central Florida conducting action research in my own classroom. This Rubric, which I found in Judith Arter's and Jay McTighe's Scoring Rubrics in the Classroom would be an asset to my research, which will examine the effects of journal writing on student achievement and attitudes in problem solving.

Respectfully,

Kelly Culbert
Princeton Elementary
culberk@ocps.net

APPENDIX J: STORY PROBLEM

Goldilocks's grandmother hands a basket of freshly made peanut-butter-and- chocolate muffins to Goldilocks and says, "These are for you, darling, but they just came out of the oven and need to cool before you can eat them. Please set them outside on the porch. You can enjoy them later."

Goldilocks thanks her grandmother and carefully places the basket on the front porch of their forest home. She then goes inside to take nap while the muffins cool.

Three bears stroll by the cottage and smell the wonderful aroma of the sweet muffins. They follow the smell right to Goldilocks's front porch and smile when they see both the nameplate on the door and the basket of marvelous muffins. Papa Bear approaches the basket first and eats exactly $\frac{1}{4}$ of the muffins. "Mmm," groans Papa Bear, "these are yummy." Next, Mama Bear eats exactly $\frac{1}{3}$ of the remaining muffins. "You are right, Papa," she declares. "These are yummy." Finally, Baby Bear goes to the basket and eats exactly $\frac{1}{2}$ of the muffins left by Mama Bear. He licks his lips and says, "Mmm, much better than porridge." The three bears pat their full bellies, smile contentedly, and continue their walk through the forest.

When Goldilocks awakens from her nap, she immediately runs to the porch to grab the basket of muffins. She is startled to discover that only 3 muffins remain in the basket. "What happened to all the muffins?" she exclaims. "I know there were more than 3 in this basket when I put it here. I wonder how many muffins were in the basket to begin with."

Use the information from this story to help Goldilocks determine how many muffins were in the basket. If Papa Bear took $\frac{1}{4}$ of the original muffins, Mama Bear took $\frac{1}{3}$ of what he left, Baby Bear took $\frac{1}{2}$ of what remained, and only 3 muffins are left in the basket, how many muffins were in the basket when Goldilocks first put them on the porch? Once you have a solution, explain to Goldilocks how you came up with your answer.

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