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The Effects Of Journal Writing On Student Attitudes And Performance In Problem Solving

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THE EFFECTS OF JOURNAL WRITING
ON STUDENT ATTITUDES AND PERFORMANCE
IN PROBLEM SOLVING

by

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for the degree of Master of Education in K-8 Mathematics and Science
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This study summarizes research conducted in a second grade classroom at a rural elementary school in the fall of 2004. This study investigated the practice of using writing activities in mathematics to improve student attitudes and performance in problem solving. The classroom teacher supplemented traditional mathematics instruction with daily problem solving activities and affective journal writing. Students were asked to complete daily problem solving prompts and write about their problem-solving solutions. Attitude data was collected using a pre and post attitude survey as well as affective journal writing assignments. Performance data was collected using a performance based problem-solving rubric. Results of this study showed change in students’ attitudes towards problem solving in the areas of willingness to participate and perseverance in completing problem solving tasks. Student performance gains were recorded and analyzed throughout the six-week study period. Thirteen out of the 17 students who participated in this study showed performance growth in problem solving.
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CHAPTER ONE: INTRODUCTION

Rationale for the Study

Research shows that writing activities enhance students’ understanding in mathematics (Connolly, 1989; Burns, 1995; Krulik & Rudnick, 1994). In his chapter, *Writing and the Ecology of Learning*, Connolly (1989) states, “‘Writing to Learn’ has replaced ‘Writing Across the Curriculum’… because it suggests the powerful role language plays in the production, as well as the presentation of knowledge” (p. 2). According to her study related to the use of writing in mathematics on second-grade student achievement and metacognition, Card (1998) found that through writing activities involving expressing mathematical thinking, problem solving, and the creation of word problems, student achievement and metacognition increased. Writing activities provide a window to students’ understanding, thought processes, attitudes, and misconceptions of mathematics concepts. Teachers also gain insight into students’ strengths, weaknesses, and interests through writing activities. Through her constructivist approach to teaching, Burns (1995) states:

> Reading students’ writing can provide valuable clues to the kinds of experiences that might be beneficial to particular individuals, not with the goal of ‘fixing’ or remediating children, but in the spirit of providing additional opportunities to help them make sense of mathematics and develop understanding of mathematical ideas and skills. (p. 30)

In her book *Writing to Learn Mathematics: Strategies That Work*, Countryman (1992) encourages all forms of journals and writing to assist in the acquisition of mathematics concepts. “Writing has given them [students] a chance to practice inferring, communicating, symbolizing,
organizing, interpreting, linking, explaining, planning, reflecting, and acting” (Countryman, 1992, p. vii).

A combination of the aforementioned research and my desire to improve my teaching led me to delve deeper into the effectiveness of writing on students’ attitudes and performance in problem solving. In my 11 years of teaching elementary school, I have witnessed students’ frustration when presented with a problem in which they did not readily know the answer. These problem-solving prompts were often written in the form of stories or word problems. A very common question asked by students when presented with this type of problem is, “Do we have to do the word problems?” Equally disturbing is the student question, “Do I have to show my work?” These questions, which were prevalent in my second grade classroom, led me to consider an instructional change in mathematics. This instructional change, I believe, can be addressed through the addition of writing in the mathematics classroom.

**Purpose of the Study**

The purpose of this action research study in which I used both qualitative and quantitative data sources was to examine my practice of using writing in mathematics. More specifically, I examined the effects of writing on students’ attitudes and performance in problem solving within a second grade classroom.

*Research Question #1*

How did my practice of including writing in mathematics affect students’ attitudes towards problem solving?
Research Question #2

How did my practice of including writing in mathematics affect students’ performance in problem solving?

Definitions

For the purpose of this study, the effects of writing on students’ attitudes and performance in problem solving, problem solving was defined as a type of mathematics problem in which a student did not readily know the answer. Writing in mathematics was a term used to describe any form of communication used to express mathematical ideas and solutions to problem solving scenarios, including, but not limited to written responses and drawings. Attitudes were students’ beliefs about problem solving in the areas of willingness, perseverance and self-confidence. Performance was described in terms of students’ growth demonstrated in the areas of understands the problem, plans a solution, gets and answer, and communicates the solution.

Throughout the research period, attitudes were measured using student journals. Student journals were a collection of student writings and responses that were thoughtful and reflective. “Alternatively called logs, notebooks, diaries, and thinkbooks, journals involve the writer in making new knowledge by making connections between new information and what is already known” (Rose, 1989, p. 17). Student journals were affective in nature and allowed the students to express opinions, feelings and reactions to problem-solving prompts.

Performance gains were measured using a holistic rubric. “A rubric is a schema that assists teachers in assessing a child’s solution to a problem based on several preset criteria”
(Krulick, 1998, p. 19). The problem solving criteria measured throughout this study was understands the problem, plans a solution, gets an answer, and communicates the solution.

Additional data were collected in the form of teacher anecdotal records. An anecdotal record was a term used to describe any form of written notes generated by the teacher while observing and questioning students about problem solving. Anecdotal records were recorded while students worked on problem-solving prompts, during group sharing time, and during focus group discussions. Group sharing consisted of whole group discussions that immediately followed the students’ independent work on the problem-solving prompt. Focus group was a term used to define a group of students assembled by the teacher to participate in teacher led discussions. These discussions were based on commonalities found in the students’ problem-solving solutions.

**Significance of the Study**

Communication is a focus of the National Council of Teachers of Mathematics (NCTM). According to NCTM (2000) *Principles and Standards for School Mathematics*,

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).

Burns’ (1995) argument for writing in mathematics posits that the mental journey called for in mathematics is fundamentally the same, as the journey required when writing. “The process of writing requires gathering, organizing, and clarifying thoughts. …Similarly, doing mathematics depends on gathering, organizing, and clarifying thoughts, finding out what you know and don’t know, and thinking clearly” (p. 3). Writing helps make connections between old and new ideas and “can provide opportunities for students to construct their own knowledge of mathematics” (Countryman, 1992, p. vi). Writing, Kenyon (1989) states “can be used effectively for the acquisition of knowledge and skills through the problem-solving process” (p. 73). Writing in problem solving requires students to clarify their thoughts and communicate how they will approach the problem. Kenyon (1989) refers to writing as problem solving. This assertion suggests that writing should be a vital part of the mathematics curriculum.

Mathematics is one of three subject areas measured on the Florida Comprehensive Assessment Test (FCAT). The FCAT is part of Florida's effort to improve the teaching and learning standards in education. The primary purpose of the FCAT is to assess student performance on the Sunshine State Standards. The Sunshine State Standards are Florida’s education principles in the subject areas of language arts, mathematics, science, and social studies. In language arts and mathematics, Grade Level Expectations have been set and have become the benchmarks for state assessments in third through tenth grades. The Grade Level Expectations have been expanded and may eventually be used to assess science and social studies benchmarks as well. A secondary purpose of this assessment is to compare the performance of Florida students to students across the nation using a norm-referenced test. In
addition to measuring student achievement, teacher performance is measured using the student achievement data from this standardized test. This teacher accountability drives the pupil progression plan as well as the mathematics curriculum in many schools. The use of writing to communicate mathematical ideas helps teachers meet the communication goal of the NCTM Standards and therefore provides a means for raising student FCAT scores.

This action research benefited myself and could potentially benefit other professionals interested in providing a comprehensive mathematics program at the elementary school level. In addition to an abundance of research already written on the subject of writing in mathematics, the results of this study will begin to validate the use of additional time and resources needed to incorporate writing in my second grade classroom. It was also my hope that I would be able to lead by example and encourage others to include writing and problem solving into existing mathematics programs. The benefits to students were improved attitudes towards problem solving, improved performance in problem-solving applications, increased student understanding, and an increased ability to communicate mathematical concepts through writing.

In the following chapter, I examined the role of problem solving in an elementary school classroom. I discussed the advantages and disadvantages of various problem-solving approaches. I explored writing in mathematics; more specifically how journal writing can be used to increase student understanding and communication of mathematical concepts. The benefits of performance-based assessment and rubrics assessment were also discussed. Finally, I investigated the important role metacognition plays in the organization and consolidation of students’ mathematical ideas.
CHAPTER TWO: LITERATURE REVIEW

Introduction

There is a plethora of research that suggests problem solving is an effective way to teach mathematics (Hohn & Frey, 2002; Countryman, 1992; O’Connell, 2000; NCTM, 2000). According to the National Council of Teachers of Mathematics (NCTM, 2000) *Principles and Standards for School Mathematics*,

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;
- monitor and reflect on the process of mathematical problem solving (p. 52).

“Problem solving is an extremely complex activity. It involves the recall of facts, the use of a variety of skills and procedures, the ability to evaluate one’s own thinking and progress while solving problems, and many other capacities” (Charles, Lester & O’Daffer, 1987, p. 7).

In my review of the literature on problem solving in mathematics, several pertinent themes became evident. These themes included students’ attitudes, performance, conceptual understanding, and ability to communicate mathematical ideas. The following summary of the literature reviews the key factors that have a profound influence on these themes.
Problem Solving Instruction

Among other techniques, there is literature that supports teaching problem solving through strategies instruction, heuristics, student problem posing, and writing. The NCTM (2000) Standards suggest strategy instruction as one aspect of problem solving. “As with any other component of the mathematical tool kit, strategies must receive instructional attention if students are expected to learn them” (p. 54). Hohn and Frey (2002) advocate heuristics. “If educators are to enhance mathematical understanding, they may need to use instructional procedures that include heuristic training” (p. 374). Problem posing is another form of problem solving cited by some researchers. “When writing their own problems, students can draw on the their experience and thereby see the relevance of mathematics to their lives” (Rudnitsky, Etheredge, Freeman & Gilbert, 1995, p. 470). Pugalee (1997) suggests “writing can be used in mathematics to assist the student in creating meaning from mathematics activities” (p. 308). Regardless of the instructional approach, ultimately “success in problem solving very much depends on the student’s interest, motivation, and self-confidence” (Charles et al., 1987, p. 7).

Instruction Using Problem-Solving Strategies

A child’s earliest experiences with mathematics come through solving problems. Whether through play, songs, or creativity, children are exposed to mathematics from a very young age. For example, a pre-school aged child can divide a set of cars into two equal piles for play with a friend without understanding the concept of equal groups, division, or sets. Different problem solving strategies are necessary as students experience a wider variety of problems (NCTM, 2000). Besides children inventing their own problem solving strategies, there are
problem-solving strategies that can be taught. Some common strategies used are choose an operation; find a pattern; make a table; make an organized list; draw a picture or diagram; guess, check, and revise; and work backward (O’Connell, 2000). In Principles and Standards for School Mathematics, NCTM recommends that teachers spend a considerable amount of time categorizing and comparing different strategies. Countryman (1992) states, “students need to know and to understand the advantages of different methods of obtaining answers” (p. 8). Therefore, it is suggested that in the early stages of problem solving, students work on recognizing different kinds of problems and discussing possible strategies to be used to solve those problems.

Teaching developmentally appropriate problem-solving strategies is an effective way to build on students’ prior knowledge. In the text Teaching Mathematics through Problem Solving, (2003) the NCTM authors suggest that students develop a deeper understanding of mathematics when they figure out how each new idea is related to something they already know. Juneja (2002) published a study in Ontario Action Researcher that demonstrated this statement by developing a problem-solving plan for her elementary classroom. During her action research studies, Juneja started each mathematics lesson with basic facts drill and a timed facts test. The key to Juneja’s class’ success was the second step in her action plan. She directly taught one of twelve problem-solving strategies each week. Juneja associated the students’ improved standardized tests from the previous year with her simple approach to teaching problem-solving strategies.
**Instruction Using Heuristic Approach**

A heuristic philosophy to problem solving is a rule and procedures based approach. Polya’s (1973) problem solving plan, which utilizes a four-step model, has proved to be an effective way to improve student’s problem-solving performance. Using Polya’s model, Hohn and Frey (2002) implemented a study focused on third, fourth, and fifth grade students that introduced a training program for problem solving called SOLVED. The acronym SOLVED represents “State the problem, Options to use, Links to the past, Visual aid, Execute your answer, and Do check back” (p. 374). Each letter of the acronym serves as a clue for the student to know what step of the problem-solving process comes next. At each grade level (third, fourth, and fifth), one class was selected to participate in the SOLVED problem-solving program. The teachers of these classes were trained in the six-step SOLVED procedures. Another class at each grade level was selected as a control group. The control groups’ teachers closely followed the steps in the teacher’s guide for the classroom text. The results of the study indicate, “elementary school students can be taught to utilize a simple heuristic strategy and that its use is associated with improved problem solving skill” (Hohn & Frey, 2002, p. 370).

In a structure-plus-writing approach, Rudnitsky et al. (1995) isolated a group of students who received “instruction based largely on practice and explicit heuristics” (p. 467). In the problem-solving treatment, students began with simple step problems and progressed to more difficult multi-step problems. The teachers in the problem-solving treatment encouraged collaborative work and modeled various solution strategies. A prominent feature of the problem-solving treatment was a large poster that outlined the following problem-solving tips: understand the problem, make a plan, use the plan, and check the answer. According to this
study, “the mean problem solving score for the solving treatment group was significantly higher than for the control group [which received no formal problem solving training]” (Rudnitsky et al., 1995, p. 481). The results of this study indicate that a heuristic approach to problem solving is more effective than no explicit instruction at all.

**Instruction Using Student Authored Problems**

There is research that suggests the best way to teach problem solving is to allow students to construct their own problems (Countryman, 1992; Winograd, 1992; Rudnitsky et al., 1995). “I believe that to learn mathematics students must construct it for themselves … by exploring, justifying, representing, discussing, using, describing, investigating, [and] predicting” (Countryman, 1992, p. 2). In a 1992 study, Winograd, an Assistant professor at Oregon State University, worked in conjunction with a fifth grade teacher to develop an alternative approach to problem solving. “We had students write and solve their own original math story problems and then share these problems with peers in small cooperative groups” (Winograd, 1992, p. 64). Throughout this process, students found their peers’ problems more interesting and challenging than textbook problems. In Winograd’s opinion, students were more interested and receptive to teacher feedback when it was enshrouded in their original problem. In their final recommendation, Winograd and his colleague state “regular instruction in a context of student-generated math story problems suggests very exciting possibilities for student learning” (1992, p. 66).

In 1995, Rudnitsky et al. conducted a study sampling third- and fourth-grade students “in which the problem solving of children taught by a structure-plus-writing approach” was
compared to a strategies based program and no formal instruction in problem solving (p. 467). The underlying assumption in the program was, “when writing their own problems, students can draw on their experiences and thereby see the relevance of mathematics to their lives” (Rudnitsky et al., 1995, p. 470). It was also assumed that in order to write a good problem, students must understand the concept underlying the problem. After 18 days of their study, the research group concluded that the structure-plus-writing group outperformed both the heuristic approach group and the control group. “The writing treatment showed itself to be remarkably powerful in its effect on problem solving, given that students in this treatment spent virtually no time actually solving problems” (Rudnitsky et al., 1995, p. 483). This research suggests that allowing students to construct their own problems is an effective way to teach problem solving.

**Instruction Using Writing in Mathematics**

Burns (1995) states that the mental journey called for in mathematics is fundamentally the same, as the journey required when writing. “The process of writing requires gathering, organizing, and clarifying thoughts. …Similarly, doing mathematics depends on gathering, organizing, and clarifying thoughts, finding out what you know and don’t know, and thinking clearly” (p. 3). Writing helps make connections between old and new ideas (Vygotsky, 1986) and “can provide opportunities for students to construct their own knowledge of mathematics” (Countryman, 1992, p. vi). According to Kenyon (1989) writing is problem solving. Writing, Kenyon states, “can be used effectively for the acquisition of knowledge and skills through the problem solving process” (p. 73). Writing in problem solving requires students to clarify their thoughts and communicate how they will approach the problem.
The use of writing in mathematics is one approach teachers can use to implement both communication and problem-solving goals in the classroom. In her book, *Writing to Learn Mathematics*, Countryman (1992) asserts, “To know mathematics is to engage in a quest to understand and communicate” (p. 9). To that same extent, the NCTM (2000) *Standards* advocate that children learn language through communication and it is important to provide opportunities for children to talk about mathematics. “Writing about mathematics, such as describing how a problem was solved, also helps students clarify their thinking and develop deeper understanding” (NCTM, 2000, p. 26). It is the above-described conceptual understanding of mathematics that has led so many researchers in the direction of writing to learn mathematics (Connolly, 1989; Countryman, 1992; Burns, 1995; Pugalee, 1997).

“Too often, children learn to compute without understanding why the computation procedures make sense” (Burns, 1995, p. 8). Burns also argues that what is missing from instruction is children “explaining the procedures they use, justifying their reasoning, judging the reasonableness of their solutions, and reflecting on their thinking” (Burns, 1995, p. 8). Reflection, Pugalee (1997) insists, is an integral part of the “normal sequence involved in communicating about mathematics” (p. 308). To promote reflection, Burns (1995) “encourages students to examine their ideas and reflect on what they have learned. …When writing about mathematics, students are actively involved in thinking and learning about mathematics” (p. 125). Being actively involved in mathematics encourages students to understand mathematics. Connolly (1989) asserts, “within the classroom, written language is more useful than oral [language]…if all students are to think, not just a dominant few” (p. 10). It is this active participation that ensures the fundamental conceptual understanding needed in mathematics.

Writing in the mathematics classroom allows students to proceed at their own rate, using their own experiences and language; increase writing fluency; combats passivity; facilitates personal engagement in learning; provides the teacher with a unique diagnostic tool; keeps a record of students’ individual travel through their mathematical experiences; and promotes a caring and cooperative atmosphere through writing interactions” (p.27).

Vygotsky (1986) contends that the permanence of print required in writing and the active nature of writing give students a way to explore thinking. Many types of writing activities including journals, learning logs, process journals, free writing, and term papers have been the subject of research (Countryman, 1992; Burns, 1995; Connolly, 1989; Rose, 1989; Pugalee, 1997; Krulick & Rudnick, 1998). Through her practical student based research, Burns (1995) developed four categories of writing: “keeping journals or logs, solving math problems, explaining mathematical ideas, and writing about thinking processes” (p. 49). Regardless of the form that writing takes, “the most important single way to helping your students learn to communicate is to provide opportunities for them to write in the mathematics class” (Krulick & Rudnick, 1998, p. 8).

**Instruction Using Journal Writing**

“‘Journal writing’ is usually used to describe a category of expressive writing that is done both in and out of the classroom, and can be either personal or academic, focused or unstructured, shared or private” (Rose, 1989, p. 25). Pugalee (1997) contends that the majority
of writing being done in the mathematics classroom is in the form of journals. The content of journal writing varies. Rose (1989) refers to summaries, explanations, problem-solving processes, questions, mathematical solutions, and feelings about mathematics all as forms of journal writing. Personal writing, in the form of informal journal writing, is the writing that helps students come to terms with new ideas (Countryman, 1992).

Noted researchers have cited that there are student benefits associated with journal writing (Krulik & Rudnick, 1998; Borasi & Rose, 1989). Burns (1995) uses journals for students to keep ongoing records about what they are doing and learning in mathematics. “Journal writing in mathematics teaching has beneficial therapeutic effect on the feelings and attitudes of students, as well as positive effect on their learning of mathematical concepts and problem solving skills” (Borasi & Rose, 1989). In addition to these affective benefits, journal writing has a positive affect on the cognitive domain as well. In their study to test the effects of journal writing on students’ achievement and attitudes towards mathematics, Jurdak’s and Zein’s (1999) “results support the hypothesis that journal writing produces cognitive benefits in mathematics achievement at the level of conceptual understanding, procedural knowledge, and mathematical communication” (p. 416).

There are pedagogical benefits to journal writing as well. Journals serve as a powerful diagnostic tool for the classroom teacher (Pugalee, 1997) and can be used for instructional decision-making (Danielson, 1999). “Good journals give evidence of students using a wide variety of thinking skills, again providing a teacher with considerable more information about how students are approaching and using mathematical concepts than most formal assignments can offer” (Countryman, 1992, p. 32). Journal writing allows for better evaluation and remediation of students and improved teacher reflection on teaching.
Despite the positive research regarding journal writing and the general principle of writing to learn mathematics, “many teachers and students resist the idea that writing belongs in math classrooms” (Countryman, 1992, p. 2). Rose (1989) gives examples of both teacher and student resistance to writing in the mathematics classroom:

Some professors resist writing assignments both because of the anticipated time to read and grade the work and because they feel untrained as a composition teacher. …Students are also reticent about writing, since most were never required to write in previous mathematics courses (p. 27).

Burns (1995) has also experienced the difficulty involved in implementing a writing program in a mathematics content course, “helping children become comfortable with writing in math class takes time and effort. First attempts are often difficult for the children and can be discouraging for teachers. However, with encouragement and practice, children improve” (p. 14). According to Countryman (1992), the benefits of writing to learn mathematics outweigh the disadvantages.

I believe that to learn mathematics students must construct it for themselves. They can only do that by exploring, justifying, representing, discussing, using, describing, investigating, predicting, in short by being active in the world. Writing is an ideal activity for such processes (p. 2).

Assessing Problem Solving

As a result of the NCTM (2000) Standards, teachers have begun using a variety of techniques to include problem solving, reasoning, traditional algorithms, and computational skills in their mathematics instruction. These additional elements create a dilemma for
classroom teachers. “A primary concern created by the highlighting of problem solving and reasoning is how to measure the students’ progress and achievement” (Krulik & Rudnick, 1998, p. 1). There is an abundance of literature that recommends various forms of alternative assessment such as rubrics, journals, portfolios, interviews, formal and informal observations, and projects (Krulik & Rudnick, 1998; Montgomery, 2000; Parke, 2001; Danielson, 1999). Danielson (1999) suggests that alternative assessment, in contrast to traditional standardized norm-referenced assessment, can offer teachers a more comprehensive evaluation of a student’s knowledge and skill in a certain field.

**Performance Assessment**

Danielson (1999) defines performances assessment as “any assessment of student learning that requires the evaluation of student writing, products, or behaviors” (p. 1). “An attraction of performance assessments is that they can allow students to demonstrate their knowledge in a variety of ways” (Parke, 2001, p. 219). Besides helping students, performance assessment is a valuable tool for teachers. Teachers can use performance assessment to identify individual student strengths and weaknesses and communicate with students and parents (Krulik & Rudnick, 1999; Danielson, 1999). Montgomery (2000) argues that, through performance assessment, “students will be engaged in complex tasks, be able to construct meaning for themselves, and self-assess to determine their strengths and goals for improvement” (p. 328). By providing authentic evidence of a student’s level of understanding, Danielson (1999) cites performance assessment as an invaluable tool to communicate with parents. Krulik and Rudnick (1998) concur, “parents are able to see evidence that their children can think and use
mathematics in situations that connect school to their world” (p. 18). In summary, performance assessment is a valuable technique to evaluate student learning in problem solving.

**Rubric Assessment**

Unlike norm-referenced tests, performance based rubric assessment is criterion-referenced in nature. “For decades…regardless of the subject matter…instruction was assumed to be the dissemination of information by teacher to students, with students showing rote memory ability via an objective test score” (Montgomery, 2000, p. 324). Objective tests and traditional assessments are desired for their obvious ease of administration and simplistic scoring (Montgomery, 2000; Krulik & Rudnick, 1998). Although not as simple as norm-referenced assessment, Krulik and Rudnick (1998) advocate rubrics as one form of performance assessment. They argue, “traditional teacher-made and standardized multiple-choice tests cannot, by themselves, provide the proper assessment of the thought processes being taught” through problem solving (p. 3).

Krulik and Rudnick (1998) defined a rubric as “a schema that assists teachers in assessing a child’s solution to a problem based on several preset criteria” (p. 19). Similarly, Montgomery (2000) defined a rubric as an “assessment tool that uses clearly specified evaluation criteria and proficiency levels to gauge student achievement of those criteria” (p. 325). This specific criterion, which are clearly defined in advance, benefits both student and teacher. By defining acceptable and unacceptable levels of performance, students and teachers can see where they need to improve, and teachers can identify concepts that need to be readdressed (Danielson, 1999; Krulik & Rudnick, 1998; Montgomery, 2000). In summary, using rubrics to assess
students’ performance tasks benefit teachers by telling students they must do a careful job, setting standards, clarifying expectations, helping students take responsibility for their own learning, and providing information to others (i.e., parents).

Among others, Pomplun, Capps and Sundbye (1998) state that rubrics can be holistic or analytic in nature. “The holistic rating is one score that reflects a rater’s overall or general impression of the quality of the student response” (Pomplun, et al., 1998, p. 97). Krulick and Rudnick (1998) refer to holistic scoring as a single grade awarded to the student based on an overall judgment of the finished product. Charles et al. (1987) state several advantages to holistic scoring scales. Holistic scales are fast assessments that focus on the process and not the answer and provide one score to describe overall performance. Charles et al. (1987) cite one limitation of this form of assessment, “[holistic scales] do not permit the pinpointing of specific strengths and weaknesses” (p. 37). This suggests that further analysis, beyond the holistic score, would be required to determine specified student strengths and weaknesses.

Charles et al. (1987) refer to “analytical scoring [as] an evaluation method that assigns point values (scores) to each of several phases of the problem solving process” (p. 30). Krulick and Rudnick’s (1998) analytical rubric uses four main categories to measure problem-solving skills. These four categories include understanding the problem, selecting a plan, carrying out a plan, and communicating a solution. Although Krulick and Rudnick (1998) advise adding creativity to the rubric, they strongly disagree with using creativity when formulating a student’s grade. Charles et al. (1987) cite many advantages to analytical scoring. Analytic scoring allows the evaluator to examine several phases of problem solving, to assign numerical value to student work, to identify specific areas of strength and weakness, to gather information on the effectiveness of instructional activities, and to allow for differential weighting of categories.
Charles et al. (1987) concede that the major disadvantage of analytical scoring is that the work being assessed might not provide enough information about the student’s thinking. Regardless of the rubric style, Parke (2001) suggests:

Well-specified rubrics are those that provide an accurate measure of students’ knowledge of the content area, specify criteria that are consistent across all items that use the same score scale, and capture students’ knowledge using an appropriate number of score levels.

(p. 218)

In contrast to traditional testing, performance assessment and rubrics are designed to measure a student’s knowledge, reasoning, communication and affective skills using various degrees of acceptability (Danielson, 1999; Krulick & Rudnick, 1998; Montgomery, 2000; Charles, 1987). Krulick and Rudnick (1998) contend that a rubric “not only provides the teacher with evidence needed to determine and support a grade, but it can also provide a diagnostic profile for each student” (p. 19). Danielson (1999) agrees,

The most powerful means teachers have at their disposal for shifting the culture of their classrooms to one of significant work is to change their assessment methodologies. If good ideas and imaginative products count, students will begin to shift their concept of the meaning of school. (p. 16)

Despite all of the positive benefits of performance assessment and rubrics, most researchers agree that performance assessment has one significant drawback. Performance assessment is time-consuming and difficult to work into classroom instructional time (Montgomery, 2000; Parke, 2001; Danielson, 1999). In addition to the relatively low-cost to administer them, Danielson (1999) states the “major advantage of multiple-choice or matching and true/false is the ease in scoring them; it does not take long to mark and answer right or
wrong” (p. 33). However, if teachers want students to acquire the problem-solving skills as outlined in NCTM (2000) Standards, Danielson (1999) insists that teachers both teach and assess those skills. “If deeper understanding is not required for the test, they [students] may not strive to achieve it” (Danielson, 1999, p. vii).

### Metacognition

Garofalo and Lester (1985) define metacognition as “choosing and planning what to do and monitoring what is being done” (p. 164). When discussing their 1985 study results, Garofalo and Lester found that “students do not routinely analyze problem information, monitor progress, or evaluate results” (p. 169). Garofalo and Lester (1985) speculate, “if the critical role of metacognition can be made more clear, educators will be better able to incorporate metacognitive aspects into mathematics instruction” (p. 172). Subsequently, Schoenfeld (1981) strongly believes that self-management is of utmost importance in problem solving. Given the above relationship between metacognition and effective problem solving, educators need to routinely incorporate these behaviors into mathematics instruction.

Pugalee (1997) and Kenyon (1989) have found that writing is logically related to the development of metacognitive behaviors. Pugalee (2001) suggests, “written words require the writer to maximally compact inner speech so that it is fully understandable, thus making necessary the deliberate structure of a web of meaning forming associations between current and new knowledge” (p. 236). The monitoring of one’s mental activities, or metacognition, is essential to using the appropriate information and strategies during problem solving. Pugalee (2001) further promotes writing “among techniques that enhance metacognitive behaviors,
writing appears to be a promising vehicle for providing the types of experiences necessary to promote the development of behaviors that are considered to be metacognitive” (p. 237).

Pugalee (2001) designed a study to investigate whether students’ written descriptions of their problem-solving methods show evidence of metacognitive behaviors. In the study findings, writing plays an important role in the learning and teaching of mathematics. Pugalee discovered “a metacognitive framework was evident in the students’ writings about their problem solving processes” (p. 242). Pugalee (2001) was further able to document a metacognitive structure similar to the one identified in Garofalo and Lester’s (1985) problem solving and metacognition research. This study provides support “for writing to function as a vehicle in supporting metacognitive behaviors identified as crucial to mathematical problem solving” (Pugalee, 2001 p. 242). This research, and others like it, is the foundation teachers need to support including writing activities in daily mathematics instruction. The documented correlations between writing and metacognition support the practice of writing to learn mathematics.

Conclusion

The significance of teaching problem solving and communicating problem solutions through writing has been discussed in the preceding review of the literature. Regardless of the problem-solving approach chosen, teaching problem solving and the subsequent sharing of ideas through writing benefit both the teacher and the student. The teacher gains insight into students’ conceptual understanding of mathematical concepts as well as any misconceptions held by students. By participating in problem-solving activities and writing about the results, students develop a deeper understanding of mathematics. “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. 52). The preceding research and review of the literature indicates that it is important for teachers to use a variety of problem-solving methods and assessments to have the greatest effect on students’ attitudes and performance in problem solving.
CHAPTER THREE: METHODOLOGY

Problem and Rationale

As an eleven-year teacher, I have observed poor student attitudes and performance in the area of problem solving. I conducted this study to determine the effects of writing on students’ attitudes and performance in problem solving. The purpose of this study was to reflect on my practice of using journal writing and problem-solving prompts in mathematics to help improve students’ attitudes and performance in problem solving.

Design of the Study

“When teachers or other professionals design and carry out their own action research, they can develop more effective ways to practice their craft” (Fraenkel & Wallen, 2003, p. 579). The results of action research can become an important source of ideas on how to modify and supplement current teaching strategies and techniques. This action research study utilized both qualitative and quantitative methods for collecting data to investigating students’ attitudes and academic performance in problem solving. The qualitative data included students’ affective journal entries, anecdotal records, and focus group discussions. The quantitative data included a pre and post attitude survey (Appendix A) and a performance rubric (Appendix B) used to assess students’ problem-solving performance.

The pre and post attitude surveys were administered and used to measure changes in attitudes towards problem solving in three categories: willingness, perseverance, and self-

24
confidence. Change was measured by comparing the mean scores from the pre and post attitude survey in each of the three categories. Daily problem-solving prompts were used to assess students’ problem-solving abilities. Students’ problem-solving performance was measured using a 12-point performance rubric that assessed performance on the following specified criteria: understands the problem, plans a solution, gets an answer, and communicates the solution. Problem-solving prompts were assigned and selected by the teacher. A sampling of problem-solving prompts is shown in Appendix C.

Assumptions and Limitations

This study was approached with the assumption that, by including writing activities with problem solving in mathematics, students’ attitudes and performance in problem solving would improve. This assumption was based on a thorough review of the related literature as well as my own professional experience. It was also assumed that students did their best on every performance task and written response assigned during the research period.

One limitation of this study was the student sample size. The study was limited to the 17 students assigned to my second grade classroom. Another limitation was the students’ participation in every writing activity and problem-solving prompt used in the study. Students were not required to make-up the assigned journal writings or problem-solving prompts following an absence.

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.

Setting

This study took place in a Central Florida elementary school located at the urban fringe of mid-size city. The elementary school provides services for students from pre-kindergarten to fifth grade. The school has received many notable accomplishments including: the Five Star School Award for four consecutive years; a school grade of “A” for four consecutive years; No Child Left Behind – 100% Adequate Yearly Progress in all categories for two consecutive years; and the Top Elementary PTA four out of the last five years. According to the October 2004 Membership, the school has 919 students, of which 463 are female and 456 are male, 50.4% and 49.6% respectively. Ethnically, the school is comprised of 696 white, 74 black, 98 Hispanic, 19 Asian, and 32 multiracial students. A very small portion of the school, 9.2% or 85 students, is considered economically disadvantaged.

The study was conducted in a self-contained, second grade classroom consisting of 18 students. Out of the 18 students assigned to this class, three students are gifted and one student is learning disabled. The learning disabled student receives mathematics instruction outside of the regular classroom and did not participate in the study. Eight of the 17 students who participated in the study were male, and nine of the students were female. The research group consisted of two Hispanic children, one multiracial child, and fourteen Caucasian children.

In addition to mathematics instruction, I taught the students reading, language arts, social studies, and science throughout the course of a school day. The mathematics instruction took
place immediately following the lunch break and lasted between forty-five and sixty minutes each day. All 17 students participated in the study from beginning to end. No students left the class, and no new students were assigned to the class throughout the duration of the study.

**Data Collection Procedures**

Prior to beginning the study, permission was sought and obtained from the University of Central Florida Institutional Review Board (IRB). Permission was granted to use the attitude survey from the National Council of Teachers of Mathematics, and permission to use the analytic rubric was granted by the publisher, Allyn and Bacon. The principal of the school approved the study, and parental consent was obtained for each of the participating students. Evidence of the aforementioned permission notifications is provided as Appendix D-H respectively. After receiving the required permissions, I read aloud a student assent script (Appendix I). All students verbally agreed to participate, and the study began. In order to respect student confidentiality, pseudonym names are used throughout this study.

The qualitative data collection for this action research included students’ journal entries, anecdotal records, and focus group discussions. The quantitative data consisted of a pre and post attitude survey (Appendix A) and a performance rubric (Appendix B) used to assess students’ problem-solving performance. The instruments used to investigate students’ attitudes and academic performance in problem solving are discussed in the following sections.
Math Journals

Each student had a designated spiral bound notebook specifically used for journal writing responses and problem-solving prompts. Students labeled this spiral bound notebook “Math Journal.” The purpose of the Math Journal was to monitor students’ attitudes through journal writing and track problem-solving performance throughout the research period.

Students were prompted to write about their problem-solving experiences, feelings, and questions throughout the research period. Weekly affective prompts were assigned and responses were written in the Math Journal (See Appendix J). The journals were collected and reviewed after each affective journal prompt was completed. Math Journals were returned to the students with responses from the teacher at the beginning of each problem-solving period.

Students’ journal responses were used to monitor changing attitudes about problem solving.

Student Math Journals were also used to collect data regarding student performance on assigned problem-solving prompts and to examine the various solutions used to solve the problem-solving prompts. After each problem-solving exercise, students brought their journals to the sharing area of the classroom. Possible answers to the questions were recorded on the board. I was careful not to pass judgment on any answer, but to record all possible answers suggested. Next, the students were encouraged to share their complete solutions orally or by writing on the board. After each solution was demonstrated, the class discussed whether or not the solution was a possible answer to the problem-solving prompt. If, through class discussion and discovery, an answer was deemed unacceptable, the error was discussed and corrected, or the solution was erased from the board. Anecdotal records from these group discussions also served as form of data collection.
**Anecdotal Records**

Anecdotal records were used to collect data throughout the study. During the research period, I observed students’ interactions while working on the problem-solving prompts and recorded this information in a spiral notebook. Additional anecdotal records included students’ questions about the problem-solving prompt, focus group discussions, and general statements made about problem solving throughout the research period. Anecdotal records were written during the class discussion period that followed each problem-solving prompt. Unique solutions were recorded and extended discussion topics were noted. This form of data collection provided information needed to assess on-going students’ attitudes and performance. Anecdotal records were also used to develop future problem-solving exercises.

**Focus Groups**

Focus group sessions were held to discuss students’ attitudes and performance in problem solving. The selected group of students was dependent on students’ problem-solving abilities and interests. For example, one focus group might consist of students who successfully solved a complex problem, while another focus group would consist of two or three students who continued to be frustrated when presented with a new problem to solve. The teacher led focus group discussions included feelings about problem solving, problem-solving solutions and strategies, and problem-solving triumphs and troubles. Occasionally, focus groups met to work cooperatively on new and unique problem-solving scenarios. The focus group discussions and problem-solving solutions were hand recorded and included among the anecdotal records. The
focus group data were used to further triangulate students’ attitudes and performance in problem solving.

**Pre and Post Attitude Survey**

Students completed an attitude survey at the beginning of the research period (See Appendix A). The attitude survey was obtained and administered according to the text *How to Evaluate Progress in Problem Solving* by Charles, Lester and O’Daffer (1987). Permission to use and adapt this instrument is provided in Appendix E. Three specific categories included in the attitude survey are: willingness to engage in problem solving, perseverance during the problem-solving process, and self-confidence with respect to problem solving. For both the pre and post attitude surveys, students were given a copy of the attitude survey and encouraged to respond honestly and without hesitation to the 20-item survey. To ensure that the students were being assessed on their attitudes towards problem solving and not their reading ability, each inventory item was read aloud and time was provided for each student to circle a “true” or “false” response. It took approximately 10 minutes to administer the pre and post attitude surveys. The participants’ answers for each question were arranged on a spreadsheet using Microsoft Excel. These data were used to further investigate students’ attitudes in the area of problem solving.

After the pre attitude surveys were collected and scored, I began the problem-solving protocol in my second grade class. I introduced the spiral bound notebooks entitled “Math Journals.” The students were given a copy of the performance assessment rubric and problem-
solving procedures (Appendixes B and K). Both of these items were secured in the spiral bound notebook entitled Math Journal.

**Performance Rubric**

In the designated spiral bound notebook entitled Math Journal, students recorded responses to a variety of problem-solving prompts (See Appendix C). The analytic rubric used to assess problem-solving performance was found in Krulik and Rudnick’s (1998) *Assessing Reasoning and Problem Solving: A Sourcebook for Elementary School Teachers*. Permission to use this instrument was obtained from the publisher and is included as Appendix F. The performance rubric is broken down into the following problem-solving characteristics: understands the problem, selects a plan, carries out the plan, and communicates the solution. Students received a score from 0-3 in each of these four categories. A copy of the performance rubric (Appendix B) was glued into the front cover of each Math Journal for students to reference during work time. Math Journals were collected at the end of each problem-solving work period, and the problem-solving responses were scored using the performance rubric. Math Journals were returned to the students at the beginning of each problem-solving session with the completed assessment information and teacher responses. This method of data collection was used to measure students’ performance on each of the problem-solving prompts.

**Credibility/Trustworthiness**

The data results were triangulated to increase credibility and trustworthiness. The triangulation of data included: affective journals, anecdotal records, focus group discussions, pre
and post attitude surveys, and rubric performance assessment. Combinations of these data were used to determine students’ attitudes and performance in problem solving.

Data Analysis Procedures

Math Journal

Students responded to a variety of problem-solving prompts (See Appendix C) throughout the research period. First, I passed out and read the problem-solving prompt aloud and offered an opportunity for questions. Next, I directed the students to the problem-solving procedures chart (Appendix K) posted in the room. The chart read: identify important information; plan a solution; solve the problem; explain how you got your answer. After reading the problem aloud and reviewing the problem-solving procedures, I allowed the students to work independently on the problem-solving exercise. Students were not encouraged to work cooperatively; however, students were not discouraged from talking to each other or from asking questions. I observed the student interactions and conversations during this independent work time and added these observations to my anecdotal notes. When approached with a student question, I would ask the student to explain what they already knew, and then I would respond with a thought-provoking question such as, “That’s an excellent question. What do you think?”

After the discussion and sharing period, the students’ problem-solving journals were collected and evaluated. Each of the four problem-solving characteristics was scored from zero to three. These scores were combined to create a holistic score for the problem-solving prompt.
In addition to the rubric score, teacher comments were added to each journal entry. Journals were returned to the students before the next problem-solving work period.

Weekly affective journal responses were also written in the Math Journal. These prompts were given on a weekly basis. Students were encouraged to share their thoughts, feelings, and questions about problem solving. The affective journal writing was also collected and teacher feedback was provided. A complete sampling of affective journal prompts is provided in Appendix J.

Anecdotal Records

As part of my routine, I regularly recorded the problem-solving prompt in a spiral bound notebook used exclusively for anecdotal records. As the students worked through the problem-solving prompts, I made notes regarding individual questions, unique solutions, students’ cooperation, common errors, and overall attitudes toward the problem. I continued to take field notes while assessing students’ work using the performance rubric. Focus group and whole class discussions were also used as an opportunity to record anecdotal notes while observing students’ interactions, attitudes, and performance. This combination of anecdotal records was used to direct problem-solving strategy lessons, create new focus groups based on interest and performance weakness, and to choose appropriate problem-solving prompts for future lessons.

Focus Groups

Weekly focus group discussions were held to further understand students’ attitudes and performances towards problem solving. Group members were chosen based on their Math
Journal responses or solutions to the problem-solving prompt. Teacher questions and prompts were the main focus of the group discussions. Students with similar solutions or errors were grouped together to discuss methods and general feelings about problem solving. The objective of the focus group sessions was to assemble students with similar interests and abilities and engage in meaningful discussions about the week’s problems. Occasionally, new problems were introduced and the focus group was encouraged to work through the problem together.

**Pre and Post Attitude Survey**

The 20-question pre and post attitude survey was written to assess students’ willingness to participate in problem solving, perseverance in completing problem-solving exercises, and self-confidence towards problem solving. Questions on the attitude survey were written for both “true” and “false” responses. Student responses in the areas of willingness, perseverance, and self-confidence were analyzed using an Excel spreadsheet. When a student responded “true” to a question written for a true response, a “1” was used to represent this question on the Excel spreadsheet. When a student responded “false” to a question written for a true response, a “0” was used to represent this question item on the Excel spreadsheet. Likewise, when a student responded “false” to a question written for a false response, a “1” was used to represent this question on the Excel spreadsheet. When a student responded “true” to a question written for a false response, a “0” was used to represent this question on the Excel spreadsheet. After each question was coded with a “0” or a “1” a raw score was generated by adding the response items together. Mean scores were generated by dividing the raw score by the number of questions in the respective category (i.e., willingness, perseverance, self-confidence). The responses from the
pre attitude and the post attitude survey were compared to determine if change in the students’ attitudes toward problem solving had occurred after participating in the use of problem-solving journals.

**Performance Rubric**

Each problem-solving exercise was scored using a three-point scale in each of the following four categories: understands the problem, selects a plan, carries out the plan, and communicates the solution listed. The four category scores were combined and each problem-solving exercise was given a holistic score from 0-12. Each holistic score was entered into an Excel spreadsheet for future data analysis. Each student’s holistic performance score was determined to be “above average,” “average,” or “below average” based on the school’s adopted grading scale. Holistic scores of 11 and 12 fell between 90-100% and were considered above average. Holistic scores of 9 and 10 fell in the 70-89% range and were considered average. Holistic scores of 8 or below fell below 70% and were considered below average.

In addition to tracking each students’ performance using the holistic score, analytic rubric scores were recorded to track students’ performance in the four problem-solving categories: understands the problem, selects a plan, carries out the plan, and communicates the solution. These data were used to monitor students’ performance growth on the problem-solving prompts.

**Conclusion**

Data from all sources listed above were recorded, triangulated, and analyzed to show the effects of writing on students’ attitudes and performance in problem solving. Data were
analyzed to identify changes in attitudes and performance. The research findings are discussed in the next chapter.
CHAPTER FOUR: DATA ANALYSIS

Introduction

Throughout my professional career, I have read a variety of literature that lists writing in mathematics as a powerful tool for overcoming students’ poor attitudes and performance in problem solving. My personal goals for this study were to reflect on my practice of using journal writing in mathematics and to collect data in support of my belief that using writing in mathematics to effect students’ attitudes and performance in problem solving.

Attitudinal themes for this study were created using the attitude survey. The pre and post attitude survey assessed students’ willingness, perseverance, and self-confidence towards problem solving. These three areas were used to generate the attitudinal themes that are discussed throughout the study. While assessing student’s attitudes and performance in problem solving, additional themes were identified from anecdotal records, student journals, observations, pre and post attitude surveys, and performance assessment. Other themes identified included an increase in students’ understanding of problem solving and an improved ability to communicate problem-solving solutions.

Students’ Attitudes

A variety of data sources were used to assess students’ attitudes towards problem solving. Pre and post attitude surveys were used to measure changes in attitudes towards problem solving in three categories: willingness, perseverance, and self-confidence. These categories served as
the attitudinal themes for this study. In addition to the pre and post attitude survey, affective
journal prompts and anecdotal records were analyzed throughout the study. A thorough review
of these data revealed common themes in regards to students’ attitudes towards problem solving.
The pre and post attitude surveys, affective journal prompts, and anecdotal records provided me
with the data needed to triangulate students’ attitudes towards problem solving.

**Willingness to Participate**

The pre attitude survey administered to the 17 students in the class at the beginning of the
research period showed a willingness to attempt problems. In the category of willingness to
solve problems there were six indicators. Three of the indicators were written for a “true”
response, and three of the indicators were written for a “false” response. When a student
responded “true” to a question written for a true response, a “1” was used to represent this
question. When a student responded “false” to a question written for a true response, a “0” was
used to represent this question. Likewise, when a student responded “false” to a question written
for a false response, a “1” was used to represent this question. When a student responded “true”
to a question written for a false response, a “0” was used to represent this. I added the response
items together and generated a raw score in the areas of willingness to participate in problem
solving. Mean scores were calculated by dividing the raw score by the number of questions in
the category of willingness to participate in problem solving. The resulting mean score
represents each student’s willingness to participate in problem solving as measured by the pre
attitude survey. The following table represents the mean scores from the pre attitude survey in
the category of willingness.
Table 1: Pre Attitude Results for Willingness

<table>
<thead>
<tr>
<th>Student</th>
<th>Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alex</td>
<td>67%</td>
</tr>
<tr>
<td>Brenda</td>
<td>100%</td>
</tr>
<tr>
<td>Carla</td>
<td>83%</td>
</tr>
<tr>
<td>David</td>
<td>100%</td>
</tr>
<tr>
<td>Evan</td>
<td>50%</td>
</tr>
<tr>
<td>Frank</td>
<td>100%</td>
</tr>
<tr>
<td>Ginger</td>
<td>100%</td>
</tr>
<tr>
<td>Hugo</td>
<td>83%</td>
</tr>
<tr>
<td>Ivan</td>
<td>50%</td>
</tr>
<tr>
<td>Jennifer</td>
<td>67%</td>
</tr>
<tr>
<td>Keith</td>
<td>83%</td>
</tr>
<tr>
<td>Linda</td>
<td>67%</td>
</tr>
<tr>
<td>Mary</td>
<td>83%</td>
</tr>
<tr>
<td>Nathan</td>
<td>100%</td>
</tr>
<tr>
<td>Olivia</td>
<td>100%</td>
</tr>
<tr>
<td>Pam</td>
<td>100%</td>
</tr>
<tr>
<td>Quinn</td>
<td>83%</td>
</tr>
</tbody>
</table>

As shown in the table above, seven out of the 17 students surveyed scored 100% in the category of willingness to attempt problem solving. An additional five students performed at or above the class average of 83%. Five students fell below the class average of 83% in the area of willingness to attempt problem solving.

At the end of the research period, the same attitude survey was administered in the form of a posttest and scored in the same manner. The intended purpose of the pre and post attitude survey was to track changes in students’ willingness to participate in problem-solving activities. The results of the pre and post attitude surveys are shown below with an additional column added to show the amount of change in the subcategory willingness.
Nine out of the 17 students showed no change in willingness to participate in problem solving activities. Of those nine students, five students’ mean scores were 100% on both the pre and post attitude survey. Four out of the 17 students showed an increased desire to participate in problem solving. Similarly, four out of the 17 students showed a decreased desire to participate in problem-solving activities.

Further analysis of my anecdotal records indicated that three out of the four students who showed a decreased desire to participate in problem solving (Brenda, Jennifer, and Nathan) had difficulty with problem solving throughout the study. During the course of the study, Brenda, Jennifer, and Nathan sought teacher assistance by asking mathematical concept questions on many of the problems presented. Jennifer needed direct teacher instruction in order to begin
thinking about the problems presented. Nathan needed direct teacher instruction and assistance reading the problem-solving prompts on a daily basis. It is difficult to understand why Quinn showed a decreased desire to participate in problem solving. As evidenced in my anecdotal records, Quinn was eager to participate in problem-solving activities and willingly participated in whole class and focus group discussions.

The students’ reflective journals also showed an improved attitude in the area of willingness. At the beginning of the research period, Alex indicated that he would write down any answer just to finish a problem and he only liked solving easy problems. At the end of the research period, this same student responded, “I like doing the math. I like solving all kinds of problems.” Similarly, Carla indicated that she did not like to solve hard problems at the beginning of the research period. Later, in a reflective journal, Carla stated, “[What] I like about problem solving is trying hard to get the answer.” Ivan indicated on the pre attitude survey that he did not like to solve problems that were hard to understand. At the end of the research period, Ivan responded to an affective journal prompt, “My most [favorite] part I like about math journal is solving the problem.”

These data, anecdotal records, and affective journal prompts indicate that most students are willing to attempt problem solving in mathematics. Thirteen out of the 17 students who participated in this study showed no change or an increase in their willingness to participate in problem-solving activities.
Perseverance

The pre attitude survey administered to the 17 students in the class at the beginning of the research period indicated that some students were hesitant to persevere when problem solving. In the category of perseverance in problem solving there were six indicators. Three of the indicators were written for a “true” response, and three were written for a “false” response. When a student responded “true” to a question written for a true response, a “1” was used to represent this question. When a student responded “false” to a question written for a true response, a “0” was used to represent this question. Likewise, when a student responded “false” to a question written for a false response, a “1” was used to represent this question. When a student responded “true” to a question written for a false response, a “0” was used to represent this. I added the response items together and generated a raw score in the area of perseverance in problem solving. Mean scores were generated by dividing the raw score by the number of questions in the category of perseverance in problem solving.

After reviewing the collected data, I found it necessary to eliminate question number ten from the survey results. Question number ten stated “I will work a long time on a problem.” In my opinion, many students misinterpreted this question to imply that they required a long time to solve problems. Students who felt confident about problem solving would not need a long time to solve most problems. The following table represents the mean scores gathered from the pre attitude survey in the category of perseverance after eliminating question number 10.
As shown in the table above, 10 out of the 17 students surveyed scored 100% in the category of perseverance. An additional four students performed at 80% in the category of perseverance. Three students fell below the class average and scored 60% in the area of perseverance in problem solving.

At the end of the research period, the same attitude survey was administered in the form of a posttest and scored in the same manner. The intended purpose of the pre and post attitude survey was to track changes in students’ perseverance in problem-solving activities. The results of the pre and post attitude surveys are shown below with an additional column added to show the amount of change in the subcategory perseverance.
Twelve out of the 17 students showed no change in perseverance in problem-solving activities. Eight of those 12 students scored 100% on both the pre and post attitude surveys. Three students showed an increased desire to persevere when problem solving. Two students showed a decreased desire to persevere in problem-solving activities.

Both Ivan and Nathan showed a decreased desire to persevere when problem solving. Once again, Nathan struggled throughout the problem-solving process and needed direct teacher instruction and assistance on the daily problem-solving prompts. In the pre attitude survey, Nathan indicated true to the following statement, “I will keep working on a problem until I get it right.” In the post attitude survey, Nathan indicated false to the same statement. Ivan responded
false to the statement, “I will put down any answer just to finish a problem” on the pre attitude survey, and he responded true on the posttest. These data suggest that Nathan and Ivan have a decreased desire to persevere when problem solving.

In addition to the data collected above, anecdotal records and student affective journal prompts were used to document students’ perseverance in problem solving. Evidence documenting an increased amount of perseverance in problem solving is found in these anecdotal records and reflective journals. Brenda, a struggling student, wrote in a reflective journal, “I like most of all [in problem solving] is making a table. It takes long but I like to do it.” At the beginning of the research period, Olivia indicated that she would stop working on problems and put down any answer just to finish. Olivia’s increased desire to persevere is evidenced in a later journal, “If it is to hard I have to ask for help. If I don’t get it then I have to ask for more help. If it is hard I try hard and I might get it right. If I don’t get it Mrs. Q helps.”

The data from above, anecdotal records, and affective journal prompts indicate that most students have a desire to persevere with problem solving in mathematics. Fifteen out of the 17 students who participated in this study showed the same amount or an increased desire to persevere in problem-solving activities.

**Self-Confidence**

The pre attitude survey administered to the 17 students in the class at the beginning of the research period showed a moderate degree of self-confidence in problem solving. In the category of self-confidence in problem solving there were eight indicators. Four of the indicators were written for a “true” response, and four were written for a “false” response. When
a student responded “true” to a question written for a true response, a “1” was used to represent this question. When a student responded “false” to a question written for a true response, a “0” was used to represent this question. Likewise, when a student responded “false” to a question written for a false response, a “1” was used to represent this question. When a student responded “true” to a question written for a false response, a “0” was used to represent this. I added the response items together and generated a raw score in the area of self-confidence in problem solving. Mean scores were generated by dividing the raw score by the number of questions in the category of self-confidence in problem solving. The following table represents the mean scores gathered from the pre attitude survey in the category of self-confidence.

Table 5: Pre Attitude Results for Self-Confidence

<table>
<thead>
<tr>
<th>Student</th>
<th>Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alex</td>
<td>63%</td>
</tr>
<tr>
<td>Brenda</td>
<td>63%</td>
</tr>
<tr>
<td>Carla</td>
<td>100%</td>
</tr>
<tr>
<td>David</td>
<td>75%</td>
</tr>
<tr>
<td>Evan</td>
<td>100%</td>
</tr>
<tr>
<td>Frank</td>
<td>100%</td>
</tr>
<tr>
<td>Ginger</td>
<td>75%</td>
</tr>
<tr>
<td>Hugo</td>
<td>88%</td>
</tr>
<tr>
<td>Ivan</td>
<td>75%</td>
</tr>
<tr>
<td>Jennifer</td>
<td>50%</td>
</tr>
<tr>
<td>Keith</td>
<td>88%</td>
</tr>
<tr>
<td>Linda</td>
<td>63%</td>
</tr>
<tr>
<td>Mary</td>
<td>88%</td>
</tr>
<tr>
<td>Nathan</td>
<td>75%</td>
</tr>
<tr>
<td>Olivia</td>
<td>88%</td>
</tr>
<tr>
<td>Pam</td>
<td>100%</td>
</tr>
<tr>
<td>Quinn</td>
<td>88%</td>
</tr>
</tbody>
</table>
As shown in the table above, four out of the 17 students surveyed scored 100% in the category of self-confidence. Five students performed above the class average of 81%. Seven out of the 17 students fell below the class average of 81% in the area of self-confidence.

At the conclusion of the research period, the same attitude survey was administered in the form of a posttest and scored in the same manner. The intended purpose of the pre and post attitude survey was to track changes in students’ self-confidence in problem-solving activities. The results of the pre and post attitude surveys are shown below with an additional column added to show the amount of change in the subcategory self-confidence.

Table 6: Pre and Post Attitude Results for Self-Confidence

<table>
<thead>
<tr>
<th>Student</th>
<th>Pre Attitude Student Responses</th>
<th>Post Attitude Student Responses</th>
<th>Change in Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alex</td>
<td>63%</td>
<td>88%</td>
<td>25%</td>
</tr>
<tr>
<td>Brenda</td>
<td>63%</td>
<td>63%</td>
<td>0%</td>
</tr>
<tr>
<td>Carla</td>
<td>100%</td>
<td>88%</td>
<td>-12%</td>
</tr>
<tr>
<td>David</td>
<td>75%</td>
<td>63%</td>
<td>-12%</td>
</tr>
<tr>
<td>Evan</td>
<td>100%</td>
<td>88%</td>
<td>-12%</td>
</tr>
<tr>
<td>Frank</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Ginger</td>
<td>75%</td>
<td>75%</td>
<td>0%</td>
</tr>
<tr>
<td>Hugo</td>
<td>88%</td>
<td>88%</td>
<td>0%</td>
</tr>
<tr>
<td>Ivan</td>
<td>75%</td>
<td>50%</td>
<td>-25%</td>
</tr>
<tr>
<td>Jennifer</td>
<td>50%</td>
<td>38%</td>
<td>-12%</td>
</tr>
<tr>
<td>Keith</td>
<td>88%</td>
<td>100%</td>
<td>12%</td>
</tr>
<tr>
<td>Linda</td>
<td>63%</td>
<td>63%</td>
<td>0%</td>
</tr>
<tr>
<td>Mary</td>
<td>88%</td>
<td>88%</td>
<td>0%</td>
</tr>
<tr>
<td>Nathan</td>
<td>75%</td>
<td>75%</td>
<td>0%</td>
</tr>
<tr>
<td>Olivia</td>
<td>88%</td>
<td>88%</td>
<td>0%</td>
</tr>
<tr>
<td>Pam</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Quinn</td>
<td>88%</td>
<td>63%</td>
<td>-25%</td>
</tr>
</tbody>
</table>
More than half (nine) of the students surveyed showed no change in self-confidence in problem solving. Two of those nine students had a mean score of 100% on both the pre and post attitude survey. Six out of the 17 students showed a decreased amount of self-confidence in problem solving. Two students showed an increase in self-confidence after using mathematics journals in problem solving.

**Students’ Performance**

Data on students’ performance were collected from a variety of sources. Journals were collected and analyzed throughout the study period. Students’ problem-solving responses were scored using a performance assessment rubric and anecdotal notes were taken after each problem-solving prompt was administered. Each problem-solving exercise was scored using a three-point scale in each of the following categories: understands the problem, selects a plan, carries out the plan, and communicates the solution. The four category scores were combined and each problem-solving exercise was given a holistic score. Each holistic score was entered into an Excel spreadsheet. These data, anecdotal records, and student response journals were used to show the effects of journal writing on students’ performance in problem solving.

These data were broken down into one-week increments throughout the course of the six-week study and analyzed. For each week, the student’s holistic scores were added together and a mean score was calculated. These data were used to place students in one of three ranges of performance: above average, average, and below average. Mean holistic scores from 11-12 on the holistic rubric were considered above average, scores from 9-10 were considered average,
and scores below nine were considered below average. Table 7 represents the average holistic rubric scores for the first week of the study.

Table 7: Summary of Performance Rubric Scores for Week 1

<table>
<thead>
<tr>
<th>Students with Above Average Score</th>
<th>Percent of Class</th>
<th>Students with Average Score</th>
<th>Percent of Class</th>
<th>Students with Below Average Score</th>
<th>Percent of Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>29.41%</td>
<td>4</td>
<td>23.53%</td>
<td>8</td>
<td>47.06%</td>
</tr>
</tbody>
</table>

During the first week of the study, five students performed in the above average range using the holistic rubric. Four students performed in the average range, and the remainder of the students, eight in all, performed in the below average range. Upon further review of the data, students who scored below the average range had difficulty in two categories: understands the problem, and communicates the solution. By contrast, the five students who scored in the above average range had little or no difficulty in these categories.

I continued with the protocol by providing problem-solving prompts the following week. The results are shown below in Table 8.

Table 8: Summary of Performance Rubric Scores for Week 2

<table>
<thead>
<tr>
<th>Students with Above Average Score</th>
<th>Percent of Class</th>
<th>Students with Average Score</th>
<th>Percent of Class</th>
<th>Students with Below Average Score</th>
<th>Percent of Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>11.76%</td>
<td>1</td>
<td>5.88%</td>
<td>14</td>
<td>82.35%</td>
</tr>
</tbody>
</table>
During the second week of the study, only two students performed in the above average range and one student in the average range. The remaining fourteen students performed in the below average range. Further study of the data showed that students who scored above average on the holistic rubric had perfect twelve point holistic scores on each of the problem-solving prompts administered. These two students were put into a focus group along with the student who scored in the average range to discuss problem-solving strategies and strengths. From that focus group, I ascertained that all three students place getting the correct answer high on their priority list. Pam responded, “I like getting the answer most of all. And I really like getting the right answer.” Both Frank and Mary responded similarly. Mary stated, “My favorite part about problem solving is checking the answer because I get to see if my answer is right or not.” Frank responded, “I like to get problems right. I don’t like to get problems wrong.” When asked what kinds of problems they like to solve, all three students indicated that they liked problems that you could draw pictures or make a chart. Pam stated, “I like problems with pictures because I can see my ideas.”

Reflective journals during the second week of the study confirmed the frustration some students were experiencing with the problem-solving prompts. When asked what students liked least about problem solving, Carla responded, “What I don’t like about solving [problems] is when I can’t get the answer. I also don’t like getting it wrong.” Ginger wrote, “The least thing I like is when I get nervous. I also hate when I don’t know what to do.” Quinn replied, “The thing I don’t like about problem solving is that some are hard!” I feel these frustrated responses are a direct result of the types of problem-solving prompts being introduced during the second week of the study. After reviewing the data from week 1, I chose more difficult problem-solving prompts. The below-average holistic rubric scores, anecdotal records from focus group
discussions, and the representative sample of reflective journals all show evidence of the mental 
struggle the students are beginning to experience.

The third week of the study indicated a slight improvement in students’ problem-solving 
performance. Table 9 illustrates the mean holistic scores for Week 3.

Table 9: Summary of Performance Rubric Scores for Week 3

<table>
<thead>
<tr>
<th>Students with Above Average Score</th>
<th>Percent of Class</th>
<th>Students with Average Score</th>
<th>Percent of Class</th>
<th>Students with Below Average Score</th>
<th>Percent of Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>11.76 %</td>
<td>4</td>
<td>23.53%</td>
<td>11</td>
<td>64.71%</td>
</tr>
</tbody>
</table>

Three additional students performed in the average to above average range on the 
problem-solving prompts during the third week of the study. Three of the students in the average 
to above average group were the same students I met with the previous week in a focus group to 
discuss problem-solving strategies and strengths. I gathered the three new students together and 
meth with them to discuss the success they experienced during the third week of the problem-
solving prompts. When asked why they thought their problem-solving scores had improved, the 
three students in the focus group had a variety of responses. Hugo suggested that he did better 
this week because he was able to do most of the work mentally. Upon further review of the 
problems assigned during Week 3, I discovered that indeed the five problems assigned could be 
solved using addition or repeated addition. Given Hugo’s mathematical ability, he would be 
capable of solving these problems mentally.
Ginger indicated that she did better this week because she was learning new ways to solve problems. Ginger stated, “I like [the problem] Sam’s Party because it has a lot of tricky things in it. I like it because there was a problem like it.” This student is referring to a similar problem from the previous week. These data indicate that the student was able to apply a strategy learned during the second week of the study. Similarly, Quinn indicated, “I liked the turkey problem where you have to count the turkey legs because it was easy.” Again, I feel that the turkey problem was easy because we had already thoroughly explored the strategy of draw a picture while discussing the previous week’s problem-solving prompts.

Table 10 illustrates the students’ rubric scores for the fourth week of the study. The number of students in the average and above average range has again increased.

<table>
<thead>
<tr>
<th>Students with Above Average Score</th>
<th>Percent of Class</th>
<th>Students with Average Score</th>
<th>Percent of Class</th>
<th>Students with Below Average Score</th>
<th>Percent of Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>29.41%</td>
<td>5</td>
<td>29.41%</td>
<td>7</td>
<td>41.18%</td>
</tr>
</tbody>
</table>

During Week 4 of the study, 10 students, or 58.82% of the class, performed in the average to above average range on the holistic rubric score. The six students from the previous weeks who scored in the average to above average range are among this group of students. The four students who had shown improved performance in problem solving were gathered together in a focus group to discuss problem solving. Two of the students, Carla and Olivia, indicated they liked the flower problem from the week. Carla stated, “My favorite problem was the flower
problem because I got it right and I like flowers.” Olivia agreed, “I like the one with the flower petals. I like it because I like drawing flowers and it was easy.” David indicated, “I like problem solving because I like to learn. I don’t like problem solving when it wastes time and makes me frustrated.” When prompted to explain what makes him frustrated, David replied, “Hard problems I don’t understand make me frustrated. They are confusing.” When asked to explain what part of problem solving is a waste of time, David responded, “Writing about the answer is a waste of time. I just want to get the answer.” Finally Linda stated, “I like all of the problems because they all got my brain thinking hard. All of the problems are great.” Although they have cited various reasons for being able to solve the week’s problem, each of these four students have displayed an improved understanding of the problem-solving process. This improved understanding translated into higher performance on the problem-solving prompts presented.

Week 5 indicated a decreased number of students who performed in the average and above average range. Nine students scored below average on the holistic rubric during the fifth week of the study. Table 11 shows the holistic scores for Week 5.

<table>
<thead>
<tr>
<th>Students with Above Average Score</th>
<th>Percent of Class</th>
<th>Students with Average Score</th>
<th>Percent of Class</th>
<th>Students with Below Average Score</th>
<th>Percent of Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>23.53%</td>
<td>4</td>
<td>23.53%</td>
<td>9</td>
<td>52.94%</td>
</tr>
</tbody>
</table>

After reviewing the performance data and anecdotal records from the week, I called two focus groups. The first group consisted of the two students who had scored in the average to
above average range for the first time. This group met to discuss their performance during Week 5. I asked Ivan and Keith to tell me about the problems they solved this week. Keith said that he liked all of the problems this week, but he really liked the spider problem. He stated, “The spider problem was really hard addition. I like hard addition, but that’s it. I don’t like other hard problems.” Ivan said that he liked solving the problems the best. He indicated, “The part I don’t like about math journals is my grades because it gets me nervous.” I showed Ivan a chart that tracked his growth in problem solving and asked him to explain it to me. He said, “My scores go up because I am understanding more problems. I still need help sometimes understanding how to do the problem.” Both Ivan and Keith have displayed improved understanding of the problem-solving process. Keith is confident in his ability to solve problems using addition equations and was able to use addition to solve a multi-step problem. Ivan understands that his increased ability to solve problems is a direct result of his increased ability to understand the problem.

The second focus group consisted of four students who consistently had a mean score of less than five on the holistic rubric scale. These students met to discuss what they liked and disliked about problem solving and how I could help them become better problem solvers. When asked to tell which problems they liked the best, Nathan and Jennifer both responded that they liked the spider problem. Nathan stated, “I liked the spider one because there was a lot of adding.” Jennifer responded, “I liked when we did the spider problem because I got a high score.” Both Brenda and Alex indicated that they liked problems from the very beginning of the problem solving journals. Brenda commented, “I liked the digit one best because it was easy. I don’t like subtracting and I don’t like making a list.” Alex stated, “I like the very first problem because it was fun. It is fun because I did it quick.” All four of these student, Nathan, Jennifer,
Brenda, and Alex are struggling with the problem-solving process. During our focus group discussion, these four students expressed that they enjoy problem solving when the solutions are simple and easy to solve.

When I asked these same four students what I could do to help them become better problem solvers, they responded with the following comments. Jennifer stated, “I need you to help me when I am stuck. Like yesterday I did not know what to do. You helped me by starting my picture.” Nathan stated, “I need help in math when I get hard or tricky problems. I also need help when I don’t understand the question. You can help by reading the problem again.” Alex’s response was, “I need help with adding and subtracting. Sometimes I think adding is subtracting and subtracting is adding.” Brenda stated, “I need help when I can not get the answer. Sometimes I think it would be good if we could use a calculator.”

The sixth week of the study showed the most improvement of all. Thirteen students, or 76% of had a mean holistic score in the average or above-average range. Only four students remained in the below-average category. All four of these students had not scored in the average to above average category throughout the study. Table 12 lists the class scores for the sixth week of the study.

Table 12: Summary of Performance Rubric Scores for Week 6

<table>
<thead>
<tr>
<th>Students with Above Average Score</th>
<th>Percent of Class</th>
<th>Students with Average Score</th>
<th>Percent of Class</th>
<th>Students with Below Average Score</th>
<th>Percent of Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>23.53%</td>
<td>9</td>
<td>52.94%</td>
<td>4</td>
<td>23.53%</td>
</tr>
</tbody>
</table>
Overall student growth was monitored and analyzed on a weekly basis throughout the six-week study using mean holistic scores as a form of measurement. By the end of the six-week period, all but four students performed in the average to above average range using the performance rubric. Student performance was also indicated in the focus group discussions. Students openly discussed problem-solving strategies and were able to indicate a preference for certain problems and express difficulties with problem solving. Some students preferred addition problems, while others indicated a preference for drawing a picture. It was also evident that students were using prior problem-solving experiences to solve similar problems. For example, in several focus group discussions students indicated that a problem was easier if a similar problem had been done in the past.

Evidence of change in students’ attitudes was shown using the pre and post attitude survey. This survey indicated that some students’ attitudes improved in the areas of willingness, perseverance, and self-confidence. Improved student attitudes were expressed in reflective journals and observed during classroom discussions and focus group discussions. All attitudinal observations were included in my anecdotal records throughout the study period. Students’ performance was documented through the use of a holistic rubric. By the end of the study, all but four students had performed in the average to above average range on the problem-solving prompts. Improved student performance was also evident in the unique solution strategies used throughout the mathematics journals. I also documented improved student performance through anecdotal records kept during group sharing and focus group discussions.
Students’ Understanding

In addition to changes in students’ attitude and performance, another theme that emerged from the research was students’ improved understanding. Fourteen out of the 17 second-grade students who participated in this study showed improved mathematical understanding. This improved understanding was evidenced in the students’ performance rubrics, reflective journals, and anecdotal records taken throughout the research period. Responses to each problem-solving prompt were assessed using a three-point scale rubric in four categories. One of those categories was understands the problem. The students’ mean scores were calculated on a weekly basis. The following table represents the students mean scores in the category of understands the problem for each week of the study.
As a whole, the class’ mean score steadily rose from 1.6 during the second week of the study to 2.4 in the sixth week of the study. As previously stated, I felt the problems used during the first week of the study weren’t challenging enough and did not fully measure the students’ ability to solve problems. Individually, four students (Frank, Mary, Pam, and Quinn) showed a strong ability to understand the problem throughout the study and therefore did not show growth over the course of the study period. Four students (Alex, Brenda, Ginger, and Keith) demonstrated a pattern of growth and improvement over a given two-week period of the study.
Six out the 17 students (David, Evan, Ivan, Jennifer, Mary, and Nathan) showed a steady increase in their ability to understand the problem. These six students demonstrated growth for three or more consecutive weeks during the study.

Throughout this study, improvement in student understanding of problem solving was evidenced not only in the performance rubric, but also through focus group discussions. Anecdotal records from the focus group discussions provided information regarding student understanding of the problem-solving prompts presented. In anecdotal notes recorded during the first half of the study, David commented, “I don’t get it,” or “I need help” on a regular basis. In a focus group discussion during the sixth week, David indicated, “I like to solve problems with equations. I like equations because you can see the math. It is fun and cool.” “Seeing the math” as this child refers to equations, shows that he is making sense of the problem and able to interpret the information provided into an equation. Further review of my anecdotal records indicated that David sought teacher assistance less often during the last half of the study. Increased mean score and anecdotal records indicate that David’s ability to understand problem solving has improved.

Another student who demonstrated a steady amount of growth was Evan. During the first three weeks of the study, Evan became easily frustrated and often did not finish the problem-solving prompt. Anecdotal records indicate that, “Evan is a bright boy who tries complex solutions but gets frustrated when they do not work out.” In a reflective journal during week 4, Evan wrote, “I dislike when the problems are hard. I dislike when the problems not good ones.” In a focus group discussion about the problems presented in week 5, Evan said, “I liked the one with Sam’s party because you could draw a picture and it was tricky.” I responded by stating, “Last week you wrote in your journal that you didn’t like hard problems. What is the difference
between tricky and hard?” Evan stated, “Last week I was frustrated. This week I can think more clearly. I like to solve problems by thinking. I am getting good at my skills in math.”

Nathan struggled with problem solving throughout the research period. Anecdotal records show that this student always had a good attitude and was willing to try. Nathan’s good attitude is also evident in his reflective journals, “I like problem solving. I like trying to solve new problems. I don’t like hard problems, but I like trying to solve them.” Nathan’s steady improvement throughout the research period can be attributed to his good attitude and willingness to try every problem. He showed a steady improvement in understanding the problem during weeks 4-6. In the sixth week of the study, Nathan scored three out of three on four consecutive problem-solving prompts. In these prompts, he identified the necessary data and question to be answered, and he illustrated the problem using pictures, equations, and a table.

In addition to improving students’ attitudes and performance in problem solving, improved student understanding of the problem was a benefit of this study. Six of the 17 students demonstrated steady growth in the category of understands the problem. This growth was evidenced in increased mean scores in the category of understands the problem, in reflective journals, and in anecdotal records.

Another theme that developed throughout the study was students’ increased ability to communicate solutions to problem-solving prompts. Group sharing became a major part of this study. Students were eager to share their solutions and discuss the variety of methods used to solve each problem. After students worked out their own solutions, the class came together to discuss the problem-solving process and the various solutions used by students. By listening to others, students became better communicators themselves.
Students’ Communication

Anecdotal records were taken during the class discussion period that followed each problem-solving prompt. A variety of solution strategies were shared and students were encouraged to read the problem-solving explanations that accompanied their solutions. Many students in my second grade classroom showed an improved ability to communicate solutions to the problem-solving prompts. This improvement was evidenced in the students’ performance rubrics, reflective journals, and anecdotal records taken throughout the research period. Each problem-solving prompt was assessed using a three-point scale rubric in four categories. One of these categories was communicates the solution. When the study began, three students were already proficient writers who consistently wrote complete explanations to accompany their problem-solving solutions, tables, pictures, or equations. As the study progressed, these students served as models for the rest of the class. By the end of the research period, eleven students showed a pattern of growth in the category of communicates the solution. An increased mean score for at least two weeks in a row during the research period evidences this growth.

Even proficient writers benefited from the problem-solving exercises and group discussions. Mary scored a mean average of 2.6 out of 3 throughout the research period. Mary’s mean scores in the category of communicates a solution steadily increased beginning the second week of the study. In response to the problem “Cubes in a Bucket,” from the first week of the study, Mary communicated the solution with an equation and this response, “How I know is because I counted the people in the class then I doubled it.” In the sixth week of the study, Mary responded to the “Lawn Mowing Problem” with a complete table and this paragraph, “How I did this problem is that first I made a chart for mowing and resting. Next I put four 30s in the
mowing column and three 30s in the resting column because he didn’t rest when he was all finished. Then I counted from 10:00 to 1:30 and got 1:30 for an answer. Mr. Gordon will finish at 1:30 p.m.” Mary’s enthusiasm for communicating solutions is evident in her desire to participate in the group discussions and in her reflective journal, “My favorite part about problem solving is checking the answer. I like it because I get to see all of the different ways you can answer the question.”

Ivan’s growth in communication is also evidenced in his problem-solving solutions, reflective journals, and my anecdotal records. Ivan’s mean score in the category for communicating a solution is 1.6 for the six-week period. Although Ivan’s mean score for the research period is low, he showed steady growth between week 2 (mean score of 1) and week 5 (mean score of 2.4) of the study. During the second week of the study, Ivan communicated his solution to the “Planting Flowers” problem with a picture and responded, “Count by 2s to see if they got the same amount of 12s in the garden.” In the fifth week of the study, Ivan included two complete equations and the following response to the “Nickel and Dime” problem, “First, I did the dimes on the ruler. Next, I did the nickels. Then I added all the numbers up. Last I found my answer. The dimes had 70 and the nickels had 45. The dimes are worth more since the nickels are 45.” Ivan’s enthusiasm for communicating was also evident in his willingness to share answers and participate in group discussions.

In addition to improving students’ attitudes and performance in problem solving, student showed an improved understanding of problem solving and an improved ability to communicate problem-solving solutions. Chapter Five will conclude my study on the effects of writing on students’ attitudes and performance in problem solving. In Chapter Five, I will review the
findings and make recommendations for future research in the area of journal writing and mathematics in a second grade classroom.
CHAPTER FIVE: CONCLUSION

The objective of this study was to examine my practice of using writing in mathematics to improve students’ attitudes and performance in problem solving. Bell and Bell (1985) suggest that improved mathematics instruction can be achieved by focusing on problem solving and expository writing. Bell and Bell posit, “Expository writing is an effective and practical tool for teaching mathematics problem solving.” (p. 212). Throughout the research period, data were collected to assist in understanding students’ attitudes and performance in problem solving through the use of a mathematics journal. Affective journal prompts, pre and post attitude surveys, and anecdotal records were used to evidence students’ attitudes about problem solving in a second grade classroom. Problem-solving prompt responses and a problem-solving performance rubric were used to measure students’ performance in problem solving. These data were collected and analyzed to provide insights into students’ attitudes and performance in problem solving. In general, my second grade class was excited about problem solving, appeared to enjoy finding unique solutions to problem-solving prompts, and eagerly shared these solutions during group discussions immediately following problem-solving exercises.

“Engaging in teacher research can contribute to better quality teaching and learning in classrooms,” (Lankshear & Knobel, 2004, p. 4). With Lankshear and Knobel’s goal in mind, I conducted action research in my second grade classroom by including problem solving and journal writing into my everyday mathematics routine. Reading students’ mathematics journals provided me the opportunity to distinguish students’ strengths and misconceptions through their affective journal prompts and problem-solving solutions. By reviewing students’ journals and analyzing students’ problem-solving prompts on a daily basis, I became a more thoughtful
practitioner. I reflected upon a combination of students’ journals and performance mean scores in order to facilitate effective instruction for the upcoming week. I believe this reflective practice enhanced my teaching ability and allowed me to successfully teach students on various levels.

“Attitudes and beliefs [towards problem solving] can be helpful or debilitating” (Charles, Lester, & O’Daffer, 1987, p. 10). In order to combat these obstacles, Charles et al. (1987) suggest that teachers should “foster the development of helpful attitudes and beliefs to dispel erroneous and debilitating ones” (p. 10). This study demonstrated the positive effects of using writing in mathematics to improve students’ attitudes towards problem solving in a second grade classroom. Students expressed their ideas and opinions about problem solving through affective journal prompts. Focus group discussions were used to further explore problem solving with students. Many students showed an apparent interest in problem solving throughout the study. Students’ willingness and perseverance towards problem solving were evident in the post attitude survey, reflective journals, and teacher anecdotal records. It is my belief that incorporating problem solving and providing time for students to communicate both orally and in writing improved students’ attitudes.

I believe that the lack of change evidenced in the category of self-confidence can be attributed to high levels of student self-esteem at the beginning of the year. The start of a new school year is mostly review. Students in my class are made to feel at ease and successful in the first weeks of school. This level of security, combined with the fact that many skills were review, could be a determining factor in the students’ high self-confidence percentages on the pre attitude survey. On a positive note, the lack of change also indicates that, even though
student were not always successful in problem solving, they still felt confident in their ability to complete a wide variety of problems as evidenced in the post attitude survey.

Another important objective of this study was to measure students’ performance in problem solving. The underlying reason behind teaching problem solving is coaching students on how to get the correct answer. By the end of the study, all but four students performed in the average to above average range using a holistic performance rubric. Improved student performance was also evident in the increasingly unique solution strategies used throughout the mathematics journals. I also documented improved student performance through anecdotal records kept during group sharing and focus group discussions. Based on the data, it is my belief that student performance was enhanced by the daily problem-solving prompts and the group discussions that followed the problem-solving exercises. Several students noted in their problem-solving journals that their improved performance was a direct result of having participated in discussions about similar problems earlier in the research period.

In addition to the improved effect writing had on students’ attitudes and performance in problem solving, two supplementary themes emerged from the data analysis. Improved student understanding and communication were evidenced in the data collected. Pugalee (1997) states, “Journals facilitate the understanding of mathematical concept because their use requires the students to collect, internalize and evaluate knowledge” (p. 1). Students’ understanding was revealed in performance rubrics, reflective journals, and anecdotal records kept throughout the research period. One of the four categories assessed using the holistic rubric was understands the problem. The class’ mean scores in the subcategory of understands the problem steadily rose from the second to the sixth week of the study. Although this was not a part of the research question, it is apparent that as students’ attitudes and performance improved in problem solving,
students’ ability to understand complex problems improved as well.

NCTM (2000) states, “writing in mathematics can also help students consolidate their thinking because it requires them to reflect on their work and clarify their thoughts about the ideas” (p. 61). Clearer communication was another unanticipated benefit of this research project. While reading students’ journals it became apparent that students’ communication skills had improved. Children were using high-level, mathematical vocabulary in their written responses and communicating solutions by providing detailed, step-by-step directions for solving problems. This increased ability to communicate was unmistakable in student journals as well as group sharing time. Daily group sharing time provided after each problem-solving exercise gave students the opportunity to share ideas and communicate individual mathematical knowledge with the class. Students eagerly shared their unique solutions to the problem-solving prompt in this risk-free and encouraging environment.

Through this study, students revealed improved attitudes and performance in problem solving. These benefits combined with students’ improved mathematical understanding, improved communication skills, and eagerness to share problem-solving solutions have encouraged me to continue implementing journal writing and problem solving in my classroom.

**Recommendations**

One limitation of this study was the small sample size. Research of this nature cannot be generalized to include all second graders. More qualitative research would need to be conducted with a larger sample size in order to generalize these findings. I believe another limitation of this study was the school setting. This study was conducted in an elementary school with a limited
amount of ethnic diversity and a relatively small portion of the school (9.2%) falling in the category of economically disadvantaged. Therefore, the results of the study could be reliant on the type of population in this particular school setting. Further research would need to be conducted in a more diverse school setting.

While conducting my research on the effects of journal writing on students’ attitudes and performance in problem solving, I often felt that a more systematic selection of problems would have facilitated the data collection process. For instance, if I had chosen to assign problems with a specific problem-solving strategy in clusters, I may have been able to more effectively track students’ understanding of problem-solving strategies. Now that the research period has ended, I plan to reassign similar problems and use this information to better understand students’ ability to apply problem-solving strategies already introduced during the research period.

Although I found focus group discussions to be a valuable tool in assessing students’ attitudes and performance in problem solving, I would have liked to use student interviews as well. In addition to fostering student-teacher rapport, I feel that personal, one-on-one interviews would provide additional insight into students’ attitudes towards problem solving. This personal form of data collection would add depth to any further research done in the area of students’ attitudes in problem solving.

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 over a longer period of time might address some of the study’s limitations. Journal entries could be written three times a week opposed to everyday, which would permit the researcher more time in between sessions to evaluate and reflect upon student’s responses.
Discussion

Bell and Bell (1985) surmise, “A program that combines expository writing with instruction in mathematic problem solving should produce measurable results” (p. 214). Through my research, I was able to measure the positive effects of journal writing on students’ attitudes and performance in problem solving. In addition to the research question, I also recorded improved student understanding and an improved ability to communicate. By incorporating writing and problem solving as a daily routine in the mathematics classroom, the students became more reflective themselves. Students who had difficulty solving problems were still capable of communicating their thought processes in writing. This method of communication was helpful because it identified what mathematical concepts students understood or misunderstood.

The data collected provided me with a clear understanding of my students’ attitudes and performance in problem solving. This newfound knowledge led to additional questions about journal writing and problem solving. One such question is: How will journal writing in mathematics effect students’ long-term attitudes and performance in problem solving? So much emphasis is placed on student performance on the FCAT standardized test. Can journal writing in mathematics have a long-term effect on students’ performance on standardized tests? These questions can be answered by tracking students’ progress throughout their academic career. I have even considered moving up to third grade with my class so that I could continue to explore journal writing and its effects on students’ attitudes and performance in problem solving. I predict, that after extensive participation in journal writing and problem solving, students would show higher performance on the FCAT standardized test.
As a result of my study, I will continue to include journal writing and problem solving as an integral part of my mathematics instruction. Besides the student benefits listed, I found journal writing and problem-solving instruction to be a valuable teaching tool. Students’ knowledge and misconceptions about mathematics concepts and strategies were evident in their writing. I was able to provide immediate and individual feedback by responding to students’ journals with suggestions for further thought or different strategy ideas. The combination of writing and problem solving in mathematics proved to be a helpful tool for improving the quality of mathematics instruction in my second grade classroom. I am optimistic that other teachers who read this research will implement similar programs that allow their students the opportunity to use journal writing to explore mathematical problem solving.
APPENDIX A: ATTITUDE SURVEY
Read each statement and circle True or False based on how you feel. There are no right or wrong answers.

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

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APPENDIX B: PERFORMANCE RUBRIC
Name: ___________________________________ Date: ____________________________

Analytic Problem Solving Rubric

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding the Problem</td>
<td>3</td>
<td>Illustrates the problem with a drawing, table, equation, <strong>AND</strong> identifies necessary data and question to be answered</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Identifies the necessary data <strong>AND</strong> question to be answered</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Only identifies necessary data <strong>OR</strong> question to be answered</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>Complete misunderstanding of the problem</td>
</tr>
<tr>
<td>Planning a Solution</td>
<td>3</td>
<td>Selects appropriate strategy and initiates implementation</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Selects appropriate strategy with no implementation <strong>OR</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selects questionable strategy and initiates implementation</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Completely Inappropriate strategy selected</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No attempt made</td>
</tr>
<tr>
<td>Getting an Answer</td>
<td>3</td>
<td>Correct answer given with appropriate work shown</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Appropriate work shown with minor computational error</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Appropriate work shown with major computational error</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No meaningful response</td>
</tr>
<tr>
<td>Communicates the Solution</td>
<td>3</td>
<td>Gives correct answer with complete explanation, <strong>AND</strong> work is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neatly presented, labeled, <strong>AND</strong> tables and/or pictures are used</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Work is neatly presented <strong>AND</strong> tables and/or pictures are used</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Tables and/or pictures are used <strong>OR</strong> work is neatly presented</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>No work shown</td>
</tr>
</tbody>
</table>

From Krulik, Stephen, And Jesse A. Rudnick, Assessing Reasoning and Problem Solving: A Sourcebook for Elementary School Teachers
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APPENDIX C: PROBLEM-SOLVING PROMPTS
1. Kristin wishes to bake some cakes. Each cake requires four eggs. How many cakes can Kristin bake if she has four dozen eggs?

2. Twenty-eight is a two-digit number whose digit sum is 10. \([2 + 8 = 10]\) How many other two-digit numbers have a digit sum of ten?

3. Jill counted the number of petals on five flowers that are all alike. When she finished she had counted 20 petals. How many petals are on each flower?

4. Which is worth more: seven inches of dimes or nine inches of nickels?

5. Put in + or – to make this statement true \([8 \_ 4 \_ 6 \_ 7 = 11]\).

6. Flopsy and Mopsy are rabbits. Mopsy eats more than Flopsy. When Flopsy eats one bowl of food, Mopsy eats three bowls of food. When Flopsy eats two bowls of food, Mopsy eats six bowls of food. If Flopsy eats five bowls of food, how much will Mopsy eat?

7. Farmer Jones has an orchard that will hold 12 trees. He will plant the same number of apple trees and pear trees. He will plant twice as many cheery trees as apple trees. How many of each will he plant?

8. Mario got one dollar from the tooth fairy. He bought one of these toys and got two coins in change. \([\text{Ball} = $.52, \text{Top} = $.86, \text{Whistle} = $.69, \text{Car} = $.74]\) Which toy did he buy? Which coins did he get in change?

9. Mike likes to collect spiders. How many eyes and legs does he see for 1 spider? 2 spiders? 6 spiders? 8 spiders?

10. Mark has a red shirt and a yellow shirt. His hats are black, brown, and blue. How many different outfits could Mark wear?
THE UNIVERSITY OF CENTRAL FLORIDA
INSTITUTIONAL REVIEW BOARD (IRB)

IRB Committee Approval Form

PRINCIPAL INVESTIGATOR(S): Christine K. Quinones

PROJECT TITLE: The Effects of Journal Writing on Student Achievement and Attitudes in Problem Solving

Committee Members:

Dr. Theodore Angelopoulos:
Ms. Sandra Browdy:
Dr. Jacqui Byers:
Dr. Ratna Chakrabarti:
Dr. Karen Dennis:
Dr. Barbara Fritzschew: (alt)
Dr. Robert Kennedy:
Dr. Gene Lee:
Ms. Gail McKinney:
Dr. Debra Reinhart: (alt)
Dr. Valerie Sims:

Full Board
[ ] Contingent Approval
   Dated: ________________

[ ] Final Approval
   Dated: ________________

[ ] Expiration
   Date: ________________

Chair
[ ] Expedited Approval
   Dated: ________________

[ ] Exempt
   Dated: ________________

[ ] Expiration
   Date: ________________

Signed: ____________________________

Chair-IRB: ____________________________

Dr. Sophia Dziegielewski

NOTES FROM IRB CHAIR (IF APPLICABLE): ____________________________

______________________________
APPENDIX E: ATTITUDE SURVEY APPROVAL LETTER
June 14, 2004

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1906 Association Drive
Reston, VA 20191-9988

Attention Copyright Permissions,

I am writing to seek permission to use information from your published text *How to Evaluate Progress in Problem Solving* (1987). 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 would be an asset to my research, the effects of journal writing on student achievement and attitudes in problem solving.

I would use the Attitude Inventory items in the form of pre- and post-test inventory for my second grade students. In as much as my students are quite young, I also request permission to add a column to the inventory with the words “true” and “false” for the students to circle in lieu of writing the words on the line as suggested.

Respectfully,

Mrs. Christin Quinones
Partin Elementary
cq11@juno.com
Dear Christin Quinones

Allyn & Bacon grants permission per your request to reprint/adapt from Assessing Reasoning And Problem Solving: A Sourcebook For Elementary School Teachers by Krulik, Stephen, And Jesse A. Rudnick for use in Your Action Research In Your Second Grade Classroom.

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We require that the following credit line be included on the first page where our material appears:

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Sincerely,

[Signature]
Suzanne Staley
Copyright and Permissions Assistant
June 14, 2004

Dear IRB Coordinator,

Mrs. Christine Quinones has notified me of the nature of her action research to take place from August 23, 2004 to November 19, 2004. It is my understanding that her action research will investigate the effects of journal writing on student achievement and attitudes in problem solving.

Mrs. Quinones 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 Christine Quinones to conduct the proposed study.

Sincerely,

[Signature]

Mr. Tim Seibert
Principal
APPENDIX H: PARENTAL CONSENT
Dear Parent/Guardian,

I am a graduate student at the University of Central Florida under the supervision of faculty member, Dr. Juli K. Dixon, conducting research on the effects of writing on student performance 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 second 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 performance 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) 320-4834 or my faculty supervisor, Dr. Juli K. Dixon at (407) 823-4140. 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,

Mrs. Christine Quinones

I have read the procedure described in the letter from Mrs. Quinones dated September 1, 2004.

I voluntarily give consent for my child, ____________________________, to participate in Mrs. Christine Quinones’ study of the effects of writing on student performance 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 I: STUDENT ASSENT SCRIPT
Good morning class. You probably don’t know that I go to school too. I take classes at the University of Central Florida in the evenings. While you are in my class this year I will be working on a research project for school. First, we are going to keep math journals to help show how much we have learned throughout the year. Next, I will be videotaping or tape-recording some of our conversations about math. 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 J: SAMPLE JOURNAL PROMPTS
1. What did you learn in math class today?
2. What was the most challenging? Why?
3. What was easiest? Why?
4. What did you learn in math class today that you didn’t already know?
5. How can you use what you learned today outside of school?
6. How did you feel about today’s lesson? Why?
7. How well do you think the class learned today’s lesson?
8. How well did you learn today’s lesson?
9. What was the most interesting part of today’s lesson?
10. How did you use mathematics today, outside of school?
APPENDIX K: PROBLEM SOLVING PROCEDURES
Steps for Problem Solving:

1. Identify the question and important information.
2. Draw a picture, make a list, or write an equation.
3. Solve the problem.
4. Explain your thinking.
   - What steps did you follow to get the answer?
   - Did you use a tool?
   - How do you know your answer is correct?
LIST OF REFERENCES

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Solutions Publications.

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