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Math in the Middle Institute Partnership
Action Research Project Report

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Department of Teaching, Learning, and Teacher Education
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Reading Mathematics

Abstract

In this study of my sixth grade mathematics class, I investigated how using reading strategies, a structured problem-solving form, and math-infused literature impacted students’ success in solving word problems and building geometric vocabulary. Direct instruction of reading strategies and the use of those reading strategies in a structured problem-solving group increased my students’ confidence in their own abilities to solve word problems. The structured problem-solving form served as a reminder of the strategies and the steps students should use when reading and solving a word problem. Students wrote in their journals that they liked the reading of the “Sir Cumference” stories, and they incorporated the geometric vocabulary from those stories into their own mathematical register. As a result of this research, I learned that in this action research period, structured group problem solving with reading strategies increased the ability of my students to solve word problems and that reading the “Sir Cumference” stories by Neuschwander helped in the development of geometric vocabulary. In the future I will use a structured group problem-solving approach after I have taught reading strategies. I intend to use the “Sir Cumference” stories to aid in geometric vocabulary and concept development.
Introduction

I chose to investigate reading strategies for problem solving that would help students to solve word problems. I wanted my students to become more independent in their ability to solve word problems and to be able to ask themselves questions that would lead to solving the problem. When students came to me because they did not know how to solve a problem or because a problem seemed to be a confusing word problem, the first thing I did was ask them to read the problem to me. Often with just reading the problem aloud, the students said, “Oh, that’s what that means.” Before this research project, students would often come into class asking questions about the difficulties with certain word problems and because I thought I did not have very much time, I immediately started talking and telling them how to do a problem or procedure. During this research period, I tried hard to just pose the problem first and then let students read the problem and solve it independently. When a student still had difficulty solving a word problem, I tried to lead the student to solve the problem by asking questions based on the reading strategies about the problem. I realized after doing my literature review that listening to explanations would not help a student if that student did not really understand what the questions in the problem were asking.

I taught mathematics, English, and science at a K-12 facility located in rural Southwest Nebraska. The structure of the K-4 classes was mostly self-contained classrooms. In fourth grade the students had two teachers, because one teacher was the elementary technology person and the other fourth grade teacher was the Title I teacher. Students at fifth and sixth grade had one teacher for language arts and social studies and a different teacher for science and mathematics. I taught science and mathematics to fifth and sixth graders, English to fifth graders, and pre-algebra to seventh graders. At seventh grade the students were split for math classes. Some of the
students took Pre-algebra 7 and the rest took Math 7. This split continued in eighth grade as
some of the students took Math 8 and the more advanced students took Algebra 1.

About 20 years ago, the school district adopted the Saxon math program written by John
Saxon and updated by Stephen Hake. I first taught fourth grade math from the Saxon book when
I was the fourth grade teacher. When I started teaching in the middle school 10 years ago I
continued to use the Saxon math books for the fifth and sixth grade students with the exception
of the pre-algebra group. The upper level mathematics teacher had chosen a different series for
the algebra classes, so I chose to use that book for seventh grade pre-algebra to help prepare
students for a different approach than the Saxon books.

The Saxon book was very structured with each problem written for a specific reason. The
sequence of teaching concepts was foreshadowing the concept, teaching vocabulary and
mathematical procedures, and then review. Every lesson used small increments of learning to
help students understand the next concept that would be taught. Each lesson had continual
review of at least 10 lessons before and questions from even earlier lessons peppered in the 25-
to 30-question homework lesson accompanying each lesson. Each question in the homework
was identified with the number of the lesson where that concept was taught. Tests were given
after every group of five lessons. The students were tested on concepts taught five to 10 lessons
before the last lesson the children did. The strength of using Saxon math was that the lessons
were taught in a logical order with lots of review and repetition. The homework was a
combination of problems that stretched the students’ computational skills and problem-solving
skills each day. One of the limitations was that the new concept was not practiced enough before
going on to the next concept. Students could work independently on almost all of the problems in
the lesson because there were only one or two new problems in the homework. That made it easy for students to work ahead or make up work when they missed school.

Our school had an elementary wing, a preschool, a central gymnasium, music, library, art, lunch area, and a separate high school building. Junior high students moved back and forth between the two buildings. There were approximately 330 students drawn from the rural area along the Republican River Valley. About 42% of the students participated in the free or reduced lunch program. The student population was mostly white, with 5% Hispanic students and 2% black or Native American children. The Hispanic students were generally fluent in English although their parents might not speak English.

The school’s improvement goal had been increasing reading comprehension and reading fluency. This was why I first began to consider the problem of reading mathematics and understanding how to solve word problems based on reading strategies. Because of our school’s interest in improving reading comprehension and fluency, I started noticing how many of the mistakes the students make in doing their mathematics lesson or in solving mathematics word problems involved reading mistakes. While teaching problem solving this year, I noticed that although the students did recognize story patterns and had a fair idea how to do the problem, they often misinterpreted the meaning of the story problem anyway.

Mathematics had its own special language involving nouns with complex situations. For example, half of the product of 3 and 4 was tricky for some students who did not understand what half of the product was. They might have misunderstood what the problem was saying unless they read the phrases carefully. My best problem-solvers would occasionally misread a small part of the problem and so they did not find the correct answer even though their thought processes on how to solve that problem were original and clever. I have had that problem myself
when attempting to solve the Math Olympiad and Mathcounts problems as well as problems in the Pre-algebra textbook. Misreading one word or a small part of the problem could make the problem a disaster. You could end up solving a problem different from the exact one being posed. So if my best students and I made mistakes with reading the problems, what a quagmire problem solving became for students who were two or even three years behind in reading levels.

For my research, I decided to use the topic of teaching reading strategies to help students read and solve mathematics word problems.

Reading mathematics was not addressed separately in the NCTM standards (NCTM 2000), but it was a part of the standards of problem solving, connections, and communication. To be an effective learner of mathematics, students must do more than compute. They had to be able to solve problems, because otherwise all of the algorithms, facts, and concepts they knew were of little use. When students could not read word problems correctly and analyze what to do based on the reading of the word problem, they became very frustrated with the process of problem solving. They were not very successful problem-solvers.

Learning through story problems that engaged students was an effective way to interest students in mathematics. Using story problems that arose out of science experiments or other activities that students were doing made learning about math more real and interesting. At first the teacher posed interesting problems and students could work together to solve them. At that point reading was done cooperatively and students had a better chance of solving the problem. When students had to read the question on their own, then that was often when the misunderstanding occurred because of limitations in students’ reading vocabularies and abilities to comprehend text.
To find connections between mathematical ideas, students must have had prior experiences with problem solving. Many times students with limited reading ability also had failed at solving word problems even though the students had fairly good computational skills and some number sense. These students might have been able to help their dads with figuring out how many bags of seed corn were needed to plant a field by talking out the problem with them. However, if they were asked to solve the same problem when reading it from a book, they might have failed to make connections because of poor reading skills and lack of a working understanding of mathematical language. Children might have seen connections with ideas in science and social studies only if they could read the situations and could understand what the book or the teacher was asking. Even fairly good readers used to skimming through fiction books need to slow down and read mathematics in a far more analytical way than how they read fiction books.

Being able to read and understand mathematics and use appropriate strategies to solve problems would make it much easier for students to do well on math lessons, tests, and problem solving. Being able to understand and solve a word or story problem would give students much more confidence in their math abilities. This topic was related to my current classroom practice in that it was important to gain reading skills to help in solving the word problems in the lessons. The students worked on the reading strategies (Zimmerman & Hutchens, 2003) of visualizing the problem, activating prior knowledge, defining terms and vocabulary, summarizing what the problem says, and testing for reasonableness after the problem was solved. The students solved word problems in groups emphasizing the reading strategies using a special form for problem solving. The students also listened and used the “Sir Cumference” books to learn geometry concepts (Capraro & Capraro, 2006). I chose the “Sir Cumference” books to use because there
was a series of four books that dealt with geometric terms. I had not used the “Sir Cumference” books in the past. The books were funny in their use of geometric terms as names of characters. The “Sir Cumference” books helped the students develop their mathematical register, a collection of math terms that would help them solve word problems and understand geometry problems.

After group activities and problem-solving sessions, the students wrote in their journals about the activity. At least once a week, they analyzed how they had performed during the activity and what they had learned. They wrote the new concepts for the activity in their own words. Journaling was another way that students could practice using their mathematical register. Journaling also helped them formulate what was the essence of the lesson and what was important to remember. Their journaling also helped me as a teacher assess what the students needed next to advance in their understanding of concepts about geometry and mathematics. As a teacher I was able to take direction from statements found in the journals of the students.

**Problem Statement**

Using reading strategies to help improve problem solving was a desirable goal. Many students struggled with problem solving when they misread the word problem. They misunderstood what the problem was asking them to do. If they did not know the question, it was hard to solve the problem. Students who consistently misread the problem or did not understand what the problem was asking would do poorly at problem solving. Real-life situations would require that a person read directions competently and fill out forms using mathematical procedures. It was important for economical reasons that bank statements, loan requirements, and insurance policies were documents that could be read by students in the future.
To communicate mathematics coherently and clearly to peers and teachers was important in the middle grades. Students who did not read the questions correctly and did not have the mathematical vocabulary necessary to explain the problems in clear ways were often embarrassed and reluctant to risk showing their thinking to others. To help students clarify what happened during their problem-solving experience, the teacher should ask the students to write what they think the problem said in their own words to first clarify what they really did read (Carter & Dean, 2006). Helping students to read the problems and then follow a systematic way of writing down the information that was in the problem might help them read mathematics more effectively, and then they might become more effective problem-solvers.

Teachers often expressed frustration that students could not understand and perform well when doing word problems. If I could find some reading strategies that would make the solving of word problems easier, both my students and the teachers that had them in the future would benefit. Students would competently solve word problems and would have confidence in their own ability to do math. Consequently, if the students were successful at problem solving, they would be more likely to enjoy math and have the desire to improve and use their problem-solving skills.

**Literature Review**

To be good mathematical problem-solvers, students must be proficient in both math computation and reading comprehension of mathematical language. Many students, who had performed poorly in math and especially in problem solving, did so because they could not read and understand what students called word problems. To be successful independent learners and problem solvers, students must be able to read, summarize, remember, and incorporate prior learning. They must have a good mathematics vocabulary and must read with much attention to
detail. Reading mathematics differed from reading, for example, a fiction book, and students must have recognized and used good reading strategies in slightly different ways when attempting to read and solve word problems.

In my review of literature, I looked for reasons that mathematics was difficult to read. I also looked for ways to help students develop reading strategies for problem solving using self-regulated techniques and group structuring. Students using self-regulated techniques would on their own remember to visualize the problem, activate prior learning, check on vocabulary, summarize the problem, and reflect on the method chosen to solve the problem. Group structuring incorporated some of the same techniques, but individual members performed the tasks within the group for the benefit of all members of the group. When I looked for these themes, I found that the type of problem chosen might help students be better problem solvers as they constructed meaning by actively participating in an area of concern for them. Finally, I found math-infused literature helped students retain math concepts by listening, reading, and summarizing the ideas in a math story.

The Teacher’s Role in Helping Students Read Mathematical Language

The language of story problems was especially hard for students to comprehend because of its specialized terms, density, long noun phrases, and normal words in the English language that took on new meaning in mathematics texts. Schleppegrell (2007) compiled research of applied linguists and mathematics educators in a review that explained why the language of mathematics was so difficult to understand. She also reviewed research that showed effective ways that teachers have developed students’ abilities to use the language of mathematics. “Mathematics is highly technical, with characteristic patterns of vocabulary and grammar. Vocabulary includes mathematics words such as *sum* or *fraction*, but also words that are not
solely mathematical but have particular meanings in mathematics, such as *place, borrow, and product*” (Schleppegrell, 2007, p.142). Consequently, just knowing the mathematics vocabulary was not enough: students must also learn the language patterns used with specific math terms. This grammatical patterning in word problems was defined by long noun phrases with qualifying adjectives used in a long string that made mathematical language hard to read. Students must have constructed meaning from these complex relationships in the word problems (Schleppegrell, 2007).

Since the language of mathematics tended to be dense and loaded with difficult phrasing, strategies for learning and understanding its grammar were important. Focusing on the way mathematics language was constructed could be a strategy for engaging students and supporting their learning. Teachers were vitally important in teaching students how to construct meaning from mathematical language (Schleppegrell, 2007). Teachers needed to constantly underscore the technical language and help the students form a bridge between the textbook and other contexts. Learning the language of mathematics took time, and teachers needed to plan how to develop precise ways of using mathematical language over lessons and units of study (Schleppegrell, 2007). Schleppegrell (2007) concluded from her review of the literature that students needed to be encouraged to talk the language of mathematics with their peer groups, write about mathematics using precise language, and demonstrate verbal knowledge of mathematical language when they engaged in class discussion.

Recognizing the difficulty of reading mathematics and the importance of the teacher in the reading process, Carter and Dean (2006) studied the ways that teachers inherently instructed students in mathematics reading strategies. They studied how teachers tutored 14 mathematically challenged students in a three-week, individualized summer intervention program provided by a
large Southern university. The teachers did not know their teaching was being analyzed for the use of reading strategies. The most prevalent strategy used by the teachers was vocabulary instruction, followed by dense questioning, and then suggesting an anticipatory guide to improve reading comprehension of a mathematical text. Another common strategy was having students read aloud and discuss each passage.

One reading strategy suggested by Carter and Dean (2006) was the activation of prior knowledge before students read the mathematical text. When teachers activated prior knowledge, they helped students see connections between what they had learned and what they were currently learning. Students also were helped to use mathematical vocabulary by discussing or recalling prior knowledge (Carter & Dean, 2006). Skilled readers used prior knowledge to predict meanings of unknown words, make inferences about what was being read, and organize new material, as well as construct meaning (Carter & Dean, 2006). Strategies to activate prior knowledge might have included brainstorming, graphic organizers, and self-questioning.

Carter and Dean (2006) also suggested the use of summarization. Using summarization, teachers could ask students to restate the problem in their own words and helped students to find relevant parts and disregard the irrelevant content. When students summarized the problem, it showed that they understood the concept and wording of the problem. Since the teacher was the guide for teaching reading and understanding of word problems to the students, the teacher needed to model this process of distilling the basic parts of the problem and using these parts to tell others about the problem.

Carter and Dean (2006) summarized the role of the teacher when they wrote:

Mathematics teachers can include reading comprehension in their mathematics instruction by asking the students to read aloud, assisting with decoding when necessary,
providing opportunities for detailed vocabulary exploration, and asking questions that help students activate prior knowledge and monitor their understanding. Reading comprehension is an essential component of successful problem solving, which is the primary goal of mathematics lessons. (p. 144)

Besides reading and solving word problems, middle-school level students also were expected to prepare for high school algebra by learning to translate verbal language into symbolic equations. There were many misunderstandings that made it difficult for middle school students to do this. Capraro and Joffrion (2006) conducted a study that “investigated the extent to which middle school student showed facility with translating English language into mathematical symbols or vice versa using conceptual or procedural indicators as measures of comprehension and vocabulary” (p. 147). Capraro and Joffrion wrote about the difference between teaching procedural and conceptual understanding. Sometimes teachers attempted to give students key words and a recipe-like list for writing algebraic equations. This might have encouraged students not to analyze the English sentences for meaning and thus reach conceptual understanding. Mathematics educators agreed that both procedural and conceptual understanding were critical for algebraic translations (2006). Capraro and Joffrion (2006) concluded that teachers should teach students a method for reflection on the equation that they had written.

Lager (2006) also studied why solving word problems could be difficult. Specifically he looked at types of mathematical reading interactions that unnecessarily hindered algebra learning and assessment. He found that just one reading misunderstanding or non-understanding led a student to create a logical, yet incorrect solution path to one item and applied that misconstruction when responding to other related problem solving. Students without a strong
command of everyday language and specialized mathematical language could not fully comprehend the content of a mathematics lesson (Lager, 2006).

Lager (2006) explained in his study that mathematical language had special structure and meanings called the “mathematical register” that a student and teacher needed to recognize. Both Lager and Schleppegrell cited Halliday as first describing the “mathematical register” in 1978. The mathematics register was a “set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings” (Halliday, 1978, p. 195). To help students understand mathematical language, the mathematics register should be used with a purpose in daily classroom mathematics lessons (Lager, 2006). Lager added that there were several “levels of linguistic conceptual abstraction” that the mathematics register did not necessarily take into account (Lager, 2006, p.192). For example, a student might have understood “square” because as a word it is less abstract than a word like “figure,” which had several meanings. Students with English as a second language and students with reading and language difficulties would need special help in learning not only the “mathematical register,” but also words that described and defined terms in the “mathematical register” (Lager, 2006, p.192).

Lager (2006) stated that to explain the components of the mathematical register in greater detail and to use the register to improve instruction; the role of the teacher must evolve. “First and foremost, every mathematics teacher must also be a language teacher” (p. 193). Teachers must have profound mathematical understanding, and they must be aware of the language they use when instructing students, anticipate the language needs of their students, and work with their students to identify any language misunderstandings. The instructor also regularly asked
students to explain their responses in both written text and discussion to check for true understanding (Lager, 2006).

These four articles by Schleppegrell, Carter and Dean, Lager, and then Capraro and Joffrion showed the importance of the teacher in teaching students to understand mathematics by giving them support and scaffolding as they first worked through word problems. They emphasized the difficulty of reading mathematics and translating mathematical language into symbols or procedure. Capraro and Joffrion (2006) also encouraged teachers to have students reflect on the work they had done. Lager’s study was different than the studies by Schleppegrell, Carter and Dean, and Capraro and Joffrion because Lager’s study involved English Language Learners (ELLs). The article written by Carter and Dean (2006) was different from the three other articles because Carter and Dean’s research involved individual students who were tutored.

Although Lager’s study involved students who were English Language Learners, the problems they exhibited were also problems my students exhibited because of low reading skills. My students also had to build their own mathematical register. Instead of individual students, English Language Learners or a specialized section, my research involved the whole class. My study pinpointed a diverse group with inclusions of very low readers and very skilled readers. So any change in using new reading strategies had to be used with the whole group, not just individual students or English Language Learners. My research was also different in that I specifically taught reading strategies, while the teachers Carter and Dean (2006) studied did not know they were being watched to see how they taught reading in mathematics class.

My research project was important because it demonstrated how a sixth grade teacher made changes in her teaching as she taught students to create their own “mathematical register.” When I approached mathematics problem solving with the intent of teaching language,
observable changes in students’ understanding and solving of problems happened. My study demonstrated the importance of recognizing the difficulty for students in a sixth grade classroom to acquire mathematical understanding of problems because of the difficulty of reading mathematical language. My study showed how my role evolved as I understood more about the language of mathematics while I assisted students to acquire a “mathematics register.”

*Developing Self-Regulated Strategies for Solving Problems by Questioning and Structured Group Work*

After students began to read mathematics successfully, the next question was how best to use that reading to foster problem solving. One classic approach for fostering problem-solving abilities outlined in many textbooks was Polya’s (1945) four-step method. Polya outlined these four phases of problem solving in his book *How to Solve It*, which was first published in 1945. In each of these four phases, students were encouraged to ask questions.

Since Polya wrote about these four steps of understanding, planning, checking, and reflecting, much research investigated the effects of teaching students such schema-based word-problem solving. The research by Jetnedra and DePipi (2002) recognized the difference between schema strategy training, which involved pattern recognition (conceptual understanding), and problem solution, which “refers to the selection and application of appropriate mathematical operations” (procedural understanding) (p.24). In their article, Jitendra and DiPipi (2002) reported on conducting an exploratory study on schema-based strategy instruction by investigating its effects on the mathematical problem solving of four middle school students with learning disabilities. They believed along with Silver and Marshall that key components of conceptual knowledge were knowledge organization and visual pattern recognition (Silver &
Marshall, 1990). For example, the ability to organize problems into categories such as distance-rate-time problems, interest problems, or discount problems was necessary for solving problems.

A suitable cognitive structure helped students to better organize problem schemata and solve problems. In this study by Jitendra and DiPipi students were taught strategies for solving multiplicative comparison problems, which allowed them to generalize the concepts to multi-step problems. The ability of the students to solve multi-step problems for which they were not trained to solve was “that schema-based instruction, with its emphasis on conceptual understanding, allowed students to successfully encode and apply the learned schemata to represent and solve multi-step problems” (Jitendra & Dipipi, 2002, p. 36).

Another strategy for effective problem solving was questioning. Butler, Beckingham, and Lauscher (2005) wrote about three in-depth case studies focused on supporting students with learning challenges to learn mathematics. The case studies documented how these students were taught to independently learn mathematics more effectively (Butler, et al, 2005). Questioning of the students played an important part of their learning. Questions focused one student’s attention on important self-regulated processes. For example, Butler, Beckingham and Lausdher (2005) wrote that:

Instructors used questions to cue task interpretation (e.g., What are you supposed to do here?), strategy development (e.g., So, how can you solve that problem?), self-assessment (e.g., So, how do you know it that worked?), and strategy revision (e.g., What can you do differently so that we get the correct answer?) (Butler et al., 2005, p. 166).

These questions followed Polya’s four phases mentioned earlier (understanding the problem, planning and checking steps, reflecting on the problem, and what was done to solve the problem).
The studies by Jitendra and DePipi and Butler, et al., focused on tutoring individual students (2005). Since I worked with the whole class, I found a study that involved structured group work. Van Garderen (2004) wrote that structured group work could help children become better problem solvers by giving them specific roles in their group and teaching strategies for solving word problems that can later be used by the student for self-regulation. Van Garderen showed how reciprocal teaching could develop the students’ comprehension of word problems (van Garderen, 2004). Brown, of the University of California at Berkeley, and Panlinscar, of the University of Michigan, developed reciprocal teaching (Brown & Palinscar, 1986).

Van Garderen (2004) proposed that teachers could use a modified version of reciprocal teaching when they were concerned about the comprehension of word problems on state assessments or daily lessons. In her article, she addressed how reciprocal teaching might have helped a specific teacher teach students how to address word problems in a structured group setting by using the four components of this modified approach: “clarifying, questioning, summarizing, and planning.” (van Garderen, 2006, p. 226). The students were divided up into groups of four students with each student in the group having a specific role. Based on the students’ abilities, accommodations could be added to aid in using reciprocal teaching. Providing a dictionary or list of terms, a chart of questions, teaching students to draw diagrams, or teaching students to underline key phrases could further help the mathematical problem solving of students (van Garderen, 2006).

What should the teacher’s role be as the students worked in structured cooperative group settings? Ding, Li, Piccolo, and Kulm (2007) examined how teachers’ interventions influenced students’ mathematical thinking in cooperative learning classroom settings. They also explained how to balance peer resource and students’ independent thinking and how to identify, diversify,
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and deepen students’ thinking. Ding, et al., concluded that effective teachers encouraged students to ask for peer help in solving problems, to discuss problems with their peers, and to elaborate their thinking as they discussed the problems. Teachers diversified students’ thinking as they guided the students through multiple approaches, praised them for their first solution, and encouraged them to try other methods to solve the problem (Ding, et al., 2007).

This study and also the prior study by Jitendra and DePipi (2002) involved small groups of students with learning disabilities. I expanded on their research by studying students with a spectrum of abilities. I wanted to see what happened when a teacher used problem solving and questioning techniques first tested on students with disabilities to help all kinds of students become more independent and self-regulated as problem-solvers.

The problem-solving methods promoted by Polya in 1945 were later echoed by the research of Butler, et al., in 2005 as they discussed questioning to figure out how to solve word problems. The van Garderen article published in 2004 described methods to help students solve problems by using a revised version of Brown’s reciprocal reading methods in a structured group setting. Jitendra and DiPipi had a different approach. They recommended that students organize problems into categories by recognizing patterns.

Although all of the articles emphasized reading for understanding and strategies to gain that understanding, Ding, Li, Piccolo, and Kulm in 2007 went a step further in recommending that a teacher’s help was needed for students to identify, diversify, and deepen their thinking. While the NCTM standards that emphasized letting students discover and actively construct meaning when solving word problems were not directly stated in these articles, the emphasis on constructing meaning was a common theme in these articles. The NCTM standards were important because textbooks and local and state assessments used the NCTM standards as the
basis for writing tests and story problems. All of these studies emphasized the teacher’s role in teaching strategies to learn how to read mathematics and do effective problem solving.

Choosing Problems

Teachers should look for problems that state ideas clearly, show different forms of the same operation in which the unknown was in a different place, and find problems that were of natural concern to the students. Problems should have a real-life basis and students should be able to actively solve the problems. That students must first understand a problem to be able to solve it was a basic tenet of Polya’s philosophy. The student also must want to solve the problem, as Polya stated:

   It is foolish to answer a question that you do not understand. It is sad to work for an end that you do not desire. Such foolish and sad things often happen, in and out of school, but the teacher should try to prevent them from happening in his class. The student should understand the problem. But he should not only understand it, he should also desire its solution (Polya, 1945/2004, p. 6).

   Searching for problems that interested and captivated students’ attention would be an important goal for the teacher. Leader and Middleton (2004) considered the effect of attitude on problem solving. By reviewing several programs, such as the Jasper Series and Decision Making that use ill-structured problem-solving activities incorporating five important attitude-strengthening elements, the authors arrived at a set of design principles that encouraged critical-thinking dispositions (Leader & Middleton, 2004). Ill-structured problems were defined as the types of problems that students would encounter in everyday practice. These problems gave students opportunities to:
(1) directly experience occasions for critical thinking, (2) engage a number of senses in
the richness of real-world problem situation, (3) react emotionally to those situation,
(4) freely choose a path to solution, and (5) engage in a series of activities that
provide opportunities for critical thinking (p. 58).

Since ill-structured problems might have multiple solutions, an important part of solving such
problems was to believe in their solution and be able to defend or promote their solutions
(Leader & Middleton, 2004). To prepare to argue for or against a solution engaged the students
and strengthened their involvement in the process of problem solving.

There were three design principles of selecting word problems that Leader and Middleton
had extrapolated from their research about ill-structured problems and their effect on students.
The first principle was that development of attitude took time, so problems might have engaged
the students for as long as two to four weeks. “Second, students need to have a stake in their
learning” (p. 66). Students needed to be involved in actual simulated situations of real-life
consequence. Third, fostering several ways to solve the problem were built into the design of ill-
structured problems (Leader & Middleton, 2004). Problems chosen by teachers would have these
principles embedded in them to foster attitudes that made the students want to solve the problem.
I was not able to use two to four weeks for one problem, but I used some of their principles in
choosing problems to interest the child. Some of the problems had multiple solutions, and I
encouraged my students to find and support more than one solution for the problems they did.

While choosing different types of word problems to use might have been one way to
change teaching methods, it also could alter the way that a teacher taught problem solving.
McDuffie and Mather (2006) studied a teacher’s transition from closely following her traditional
district curriculum to selecting problems from outside sources during the course of one school
year. At the same time, she changed her practice to focus more on students’ mathematical thinking and their communication of that thinking. During this change in practice, the teacher began to choose problems specific to her students’ instructional needs, viewing the problems as instruments to meet her students’ needs. In this case study, the teacher learned to make problems work for her objectives and not let the problems decide the course of her instruction (McDuffie & Mather, 2006).

Lerenz, the teacher in the study, by working closely with McDuffie, was able to select problems from other resources to teach topics in the textbook based on what the students needed. Lerenz started planning lessons by asking herself what her students needed to learn and what approaches she could use so that students could have made sense of the concepts and processes. “Lerenz reified instructional materials as objects or tools for her teaching and her students’ learning” (p. 456). Lerenz stated that without the support of McDuffie and access to McDuffie’s instructional materials she would not have been able to make these changes in her practice. Support for new instructional practices made it much easier for her to change.

Where did a teacher look for problems and ideas that are interesting and would have engaged students in real-life problems with multiple outcomes? Seaman (2003) outlined in his article how he went about finding real-life problems for his work by “keeping a file in which he put clippings, articles, and the like that he thinks might have some real-world applications to supplement his teaching of mathematics” (Seaman, 2003, p.1). NCTM (2000) recognized that in grades six to eight “many interesting problems can be suggested by everyday experiences, such as reading literature or using cellular telephones, in-line skates, kites and paper airplanes” (p. 256). Teachers might have chosen interesting problems from many different news sources.
Reeder, Cassel, Reynolds, and Fleener (2006) explored how classroom environments might have been affected when teachers thought about mathematics curricula differently and began to change according to calls for reform that emphasized rich problem-solving environments. Their study described how two teachers changed their teaching as they tried to implement new ideas about mathematics. Kathleen, the second grade teacher, conducted her class in small groups or pairs that worked on problem solving together. She specifically chose problems based on the conversations and felt that she stayed focused on the “big ideas of mathematics rather than limiting the curriculum to expected grade-level learning objectives” (Reeder et al., 2006, p. 56). Wesley, an eighth grade teacher, also used problem-centered inquiry. Wesley created mathematical meanings and conceptual learning by providing students with mathematical tasks that gave them the freedom to “interact and collaborate with their peers” (Reeder et al., p. 58).

Choosing problems was the theme that these articles had in common. Seaman (2003) chose problems from real-life news stories. Leader and Middleton (2004) recommended choosing problems that children would encounter in everyday practice. These problems might not always have had one solution and they might not be able to be solved in one day. McCuffie and Mather’s article in 2006 followed a teacher who chose her own problems based on what she saw her students needed. Reeder, Cassel, Reynolds, and Fleener (2006) also studied two teachers who made the change advocated by NCTM and chose their own problems and curriculum based on observations about their students.

**Math-infused Literature**

Another source of materials and problems used in the classroom came from math-infused literature. Capraro and Capraro (2006) analyzed how one teacher used the “Sir Cumference”
books (Neuschawander, 1997, 1999, 2001, 2003) to supplement geometry taught at the middle grade level. “The students using the math-infused literature showed fluency with geometry vocabulary, demonstrated flexibility in the application of geometry concepts, explained formulae with rich descriptions, and out-performed the non-story group on geometry ability” (Capraro & Capraro, 2006, p. 21).

Adams and Lowery (2006) looked at how students read mathematics. This article showed how two fourth grade students were engaged in reading a children’s trade book with embedded mathematics and then how these same children read from their mathematics textbook. The students used experiences or background learning that they had to assist them with the mathematics in the trade book and used concepts in an informal way to respond to problems in the textbook (Adams & Lowery, 2007).

In the study by Adams and Lowery, the page the students read from their textbook had a focus on measurement including dimensions, area, and perimeter. As they read from their textbook, they showed mathematical knowledge of perimeter and area, but did not use a formula to show their results. As students read from their textbook, students needed to master the language of mathematics so they could have better communicated their understanding of the subject. Students must be guided to notice the embedded mathematics in trade books (Adams & Lowery, 2007).

Both Adams and Lowery (2007) and Capraro and Capraro (2006) focused on a new trend in writing about mathematics in children’s literature. While Capraro and Capraro focused mainly on the geometry content in the “Sir Cumference” books and how it enhanced a student’s understanding of mathematical terms, Adams and Lowery focused on how students looked at the solving of problems infused in the literature. Adams and Lowery noticed how the students used
background knowledge they possessed in discussing both the math-infused literature and their math textbook, but the students did not naturally make the connection from general discussion and solving of the problem to using a formula involving area and perimeter.

**Purpose Statement**

The purpose of my study was to improve student problem solving through a structured group plan to help students gain in reading comprehension of word problems. I examined the research themes of using a structured group method for reading and solving problems, using reading strategies and math-infused literature to improve independent problem solving, providing interesting group problems for students to solve, and finding ways for me, as a teacher, to better understand students’ problem solving by having students communicate using a journal with specific journal prompts about problem solving. By using journals and other data collection methods I sought the answers to these research questions:

1. What happens to students’ problem solving when I have them work in groups with a structured plan involving reading strategies to solve problems?

2. What happens to students’ understanding when they are taught reading strategies for reading mathematics using math-infused literature and story problems about areas of concern for them?

3. What happens to my classroom when I have students work in structured groups to do problem solving, when I teach reading strategies for mathematics, and when students write in their journals after problem solving?

**Method**

My research started on 2/02/09, when I received notice of IRB approval. On Wednesday, 2/03/09, I had prepared the forms to hand out to my sixth grade class. On Thursday, 2/04/09, my teaching colleague handed out the permission forms to the sixth grade class. At that time there
were 22 students in the sixth grade class with five students receiving Title 1 help with their math during study hall. In the following two weeks, two students left the sixth grade class because of family problems. By Monday, 2/09/09, the other 20 students had returned the permission forms. Only one student declined to be part of the research.

On Friday, 2/05/09, I gave the attitude survey (see Appendix A) to the sixth grade students. I administered this survey again on 4/27/09, at the end of the research period. Because I wanted an idea of how the students worked to solve a word problem, on 2/09/09, I had students write a journal entry about how they solved word problems. This was the first of 10 journal entries that the students wrote for me using journal prompts (see Appendix B). Each week I also had a journal prompt (see Appendix C). Besides the journal prompt, I found myself journaling about my feelings and frustrations as I went through this research project. The journal prompts were targeted to specific lessons or concepts. As the project went on, I got further and further behind in the lessons we were doing and so I had to modify the prompts based on where we were in the lessons.

This time has been particularly stressful for me. Some unexpected family circumstances disrupted data collection at times. Also with the students’ regular sickness and planned vacation for sporting events during March, the time seemed to fly. The town’s boys’ basketball team qualified for state and that week was not conducive to learning. I also had two days where I was gone for Mathcounts competition. My Mathcounts team qualified for state competition on March 21, but that made more work for me in March when I had figured we would be done with Mathcounts for the year. The last two weeks in March involved ITBS testing and State Assessment testing. Because of these disruptions, my planned timetable for data collection was no longer accurate. I fell way behind in the lessons I had planned to introduce and the journal
prompts that were connected to those lessons. I had to rewrite journal prompts for Journals 6, 7, 8, and 9.

Many of my sixth grade students were gone to a nearby town for vocal clinic on 2/12/09. This, however, was fortunate because I discovered how confused the remainder of the students was about geometric terms. I then gave all of the students a test on geometric terms before we read the “Sir Cumference” books. I gave that same test on 4/27/09 (See Appendix D) to see if the students had gained in their understanding of geometric terms.

After the pre-survey and pre-journal activities, I spent two days, 2/10/09 and 2/11/09, teaching the reading and mathematical strategies of visualization, activating prior knowledge, reviewing vocabulary, summarization, looking for patterns, solving a simpler problem and reflecting about what was done. Students practiced visualization two ways that first day – by drawing and by acting out the problem. I reviewed the patterns that they had learned earlier during the school year – Some and Some More, Some Went Away, Larger-Smaller-Difference, Later-Earlier-Difference, and Equal Groups. I discussed with them how to activate prior knowledge by checking in the glossary or appendix of the mathematics books, reviewing past lessons, or checking with a friend. On the second day the students worked with Math Olympiads problems as examples and tried to summarize what the problems were asking them to do. After they solved the problems as a group, they reflected about whether their problems could be solved in another way, how they knew if their answer was reasonable, and discussed the strategies they had used to solve the problem.

On 2/11/09, I introduced the structured problem-solving form that I had created to help students recall the reading strategies and approach solving problems in a systematic way. The students worked in groups of three or four students to solve word problems chosen from the
Math Olympiads test using the structured problem-solving form (see Appendix E). Following that initial problem-solving effort, the students used the problem-solving form for group work at least once a week. I kept the forms and the word problems they used to show the work that the students did and how they used the form.

Toward the end of the research period, I showed the students the problem-solving rubric (see Appendix F) that I had created to see if they were communicating how the problem was solved. The rubric had a five-point scale, with the best response incorporating these points: student selects and implements relevant concepts and procedures, student shows evidence of executing a plan and checking steps along the way, student shows all work necessary to solve the problem, the solution and all relevant work are correct, and the student has an incorrect answer. I collected two examples of problem solving the students did, which I scored with the rubric.

I interviewed at least two students a week using the interview questions I created. At first, I tried using a tape recorder. I taped a copy of interviews, but then the tape recorder broke and I decided I was doing just fine recording what the students told me as I conducted the interview. See the interview questions on Appendix G. I also conducted a problem-solving session (see Appendix H) with an Advanced student, a Proficient student, and a Progressing Student, using five problems pre-selected from the Saxon math series. I did two of these sessions with each student to see if there were any changes. During this time, I also kept some of their tests from the Saxon math book. The tests were administered after five lessons and checked the students’ ability to use math skills and understand concepts taught in the previous 10 lessons.

I had hoped to collect lessons that would show how much better the students were doing based on improving their reading of word problems. In my observation as a sixth grade mathematics teacher, there was always difficulty at the end of the sixth grade year. Students had
to assimilate all of the fraction and decimal concepts, as well as have the geometric concepts of perimeter, area, and volume in their bank of knowledge. As students had more and more difficulty, I put off collecting their daily work, so I had less work as examples than I had originally planned. Because of doing more group activities, there became less time to teach the lessons in the Saxon book. I had to rearrange the order of lessons and skipped seven lessons, so that I could read the last “Sir Cumference book” and do the journal prompt that went with it. See Figure 1 for what was planned for data collection, and then see Figure 2 for what actually happened. Figure 3 shows a timeline of data collection and interruptions.
<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1st Data Collection Procedure</strong></td>
<td><strong>2nd Data Collection Procedure</strong></td>
</tr>
<tr>
<td>Interview small groups of students about their problem solving groups.</td>
<td>Keep records of assignments &amp; journal of teacher thoughts in selecting certain problems and designing problem solving assignments</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>Assignments: weekly</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Journal: weekly</td>
</tr>
<tr>
<td>After school, last two weeks of April, 2007</td>
<td>Feb 1-April 15</td>
</tr>
<tr>
<td><strong>What happens to student’s understanding when they are taught reading strategies for reading mathematics using math-infused literature and story problems about areas of concern for them?</strong></td>
<td><strong>Keep a teacher journal to record observations of how students respond to math-infused literature and story problems about areas of concern for them.</strong></td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Assign structured journal responses once a week</td>
</tr>
<tr>
<td>Feb 1-April 30</td>
<td>Feb 1-April 30</td>
</tr>
<tr>
<td><strong>What happens to my classroom when I have students work in structured groups to do problem solving, when I teach reading strategies for mathematics, and when students write in their journals after problem solving?</strong></td>
<td><strong>Student surveys used before and after the intervention of math-infused literature and structured group problem solving using areas of concern for them.</strong></td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>February 1 and April 15</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Feb 1-April 15</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Research Questions</th>
<th>1st Data Collection Procedure</th>
<th>2nd Data Collection Procedure</th>
<th>3rd Data Collection Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What happens to students’ problem solving when I have them work in groups with a structured plan to solve problems?</td>
<td>Interviewed students in pairs or individually about their problem solving groups, attitudes, and feelings about math.</td>
<td>Kept records of assignments &amp; journal of teacher thoughts in selecting certain problems and designing problem solving assignments</td>
<td>Kept students' problem solving assignments; scored with a rubric</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>Starting March 19,</td>
<td>Assignments: weekly</td>
<td>April 3, April 29</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>During study hall once or twice a week until April 21</td>
<td>Feb 1-April 27</td>
<td>Feb 1-April 30</td>
</tr>
<tr>
<td>What happens to student’s understanding when they are taught reading strategies for reading mathematics using math-infused literature and story problems about areas of concern for them?</td>
<td>Kept a teacher journal to record observations of how students respond to math-infused literature and story problems about areas of concern for them?</td>
<td>Checked the journal responses of students to see how they feel about using math-infused literature and story problems about areas of concern for them.</td>
<td>Kept copies of student tests and teacher grade book to measure mathematics achievement, kept data from Math Olympiads Tests Tested geometry terms twice</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>Weekly</td>
<td>Assigned structured journal responses once a week</td>
<td>Approximately 4 tests and data from monthly Math Olympiad Tests</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Feb 1-April 30</td>
<td>Feb 1-April 30</td>
<td>Feb 1-April 30</td>
</tr>
<tr>
<td>What happens to my classroom when I have students work in structured groups to do problem solving, when I teach reading strategies for mathematics, and when students write in their journals after problem solving?</td>
<td>Administered student surveys used before and after the intervention of math-infused literature and structured group problem solving using areas of concern for them.</td>
<td>Picked 3 students one advanced, one proficient, and one progressing, Interviewed them at the middle of the intervention and again at the end of the intervention using a similar problem solving situation.</td>
<td>Kept a journal to record observations of how I felt about the interventions I have made.</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>February 1 and April 15</td>
<td>March 2 and April 28</td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Feb 1-April 30</td>
<td>March 2 and April 28</td>
<td>Feb 1-April 30</td>
</tr>
</tbody>
</table>
**Figure 3: Summary of Data Collected and Interruptions**

<table>
<thead>
<tr>
<th>Date</th>
<th>Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 5</td>
<td>Attitude Survey</td>
</tr>
<tr>
<td>February 9</td>
<td>Pre-journal about how to solve problem</td>
</tr>
<tr>
<td>February 10-11</td>
<td>Taught about reading strategies, Introduce problem-solving form</td>
</tr>
<tr>
<td>February 12</td>
<td>Discovered students have trouble with geometric terms</td>
</tr>
<tr>
<td>February 13</td>
<td>Pretest on Geometry terms</td>
</tr>
<tr>
<td>February 17</td>
<td>Journal 1</td>
</tr>
<tr>
<td>February 18-24</td>
<td>Arizona Trip</td>
</tr>
<tr>
<td>February 26</td>
<td>Review Strategies, Use problem-solving form for Lesson 80, Question 1, Picked up Lesson 78 for data</td>
</tr>
<tr>
<td>February 27</td>
<td>Journal 2 for students about problem-solving Lesson 80</td>
</tr>
<tr>
<td>March 2</td>
<td>Interview Advanced, Proficient, and Progressing</td>
</tr>
<tr>
<td>March 3</td>
<td>Read Sir Cumference and the First Round Table</td>
</tr>
<tr>
<td>March 5</td>
<td>Did pen problem and Journal 3</td>
</tr>
<tr>
<td>March 8</td>
<td>Math Olympiad Test with Problem Solving Form</td>
</tr>
<tr>
<td>March 11</td>
<td>Group Problem on Surveys and Journal 4</td>
</tr>
<tr>
<td>March 12-13</td>
<td>State Boys’ Basketball</td>
</tr>
<tr>
<td>March 16</td>
<td>Made polyhedron in group and filled out chart</td>
</tr>
<tr>
<td>March 17</td>
<td>Workshop on autism</td>
</tr>
<tr>
<td>March 18</td>
<td>Read Sir Cumference and the Sword in the Cone</td>
</tr>
<tr>
<td>March 19</td>
<td>Journal 5 about the Sword in the Cone Interviews: Danny, Tom, Sabrina, Nancy</td>
</tr>
<tr>
<td>March 22-27</td>
<td>ITBS Testing</td>
</tr>
<tr>
<td>March 27</td>
<td>Journal 6 about problem solving</td>
</tr>
<tr>
<td>March 30</td>
<td>Interview David, Caden, Leah, Carmen</td>
</tr>
<tr>
<td>March 31</td>
<td>Doctor’s Appointment</td>
</tr>
<tr>
<td>April 1</td>
<td>Assessment 6.2.2</td>
</tr>
<tr>
<td>April 2</td>
<td>Monopoly Group Work, Interview with Bill, Tyler, Bob, and Sarah</td>
</tr>
<tr>
<td>April 3</td>
<td>Interview with Shelly and Melissa,</td>
</tr>
<tr>
<td>Date</td>
<td>Activity</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>April 6</td>
<td>Odd problems on Lesson 95, Read Sir Cumference and the Secret of Pi</td>
</tr>
<tr>
<td>April 8</td>
<td>Group Activity on Diameter, Circumference, and Pi</td>
</tr>
<tr>
<td>April 9</td>
<td>Journal 7 about Diameter, Circumference, and Pi</td>
</tr>
<tr>
<td>April 10-13</td>
<td>Easter Vacation</td>
</tr>
<tr>
<td>April 14</td>
<td>Interview with John, Lily, Ted Problem Solving with rubric on Algebra ½ problem</td>
</tr>
<tr>
<td>April 16</td>
<td>Journal 8 about reading strategies, working in groups, Sir Cumference stories, instead of doing original journal</td>
</tr>
<tr>
<td>April 20</td>
<td>Doctor’s appointment</td>
</tr>
<tr>
<td>April 21</td>
<td>Attitude survey</td>
</tr>
<tr>
<td>April 21</td>
<td>Skipped ahead to Lesson 107 on Angles, Take extra class period to Read Sir Cumference and the Knight of Angleland</td>
</tr>
<tr>
<td>April 22</td>
<td>Doctor’s appointment</td>
</tr>
<tr>
<td>April 23</td>
<td>Field trip</td>
</tr>
<tr>
<td>April 24</td>
<td>Journal 9 about Sir Cumference and the Knight of Angleland</td>
</tr>
<tr>
<td>April 27</td>
<td>Geometry posttest</td>
</tr>
<tr>
<td>April 28</td>
<td>Interview with Advanced, Proficient, and Progressing Student</td>
</tr>
<tr>
<td>April 29</td>
<td>Problem Solving with Rubric on ratio</td>
</tr>
</tbody>
</table>
Findings

During this action research period, I actually had two different kinds of average days of teaching. I had a more traditional approach on the days that we did lessons from the Saxon book. The 2001 Edition of the Sixth Grade Saxon book had 30 problems every day. Each problem referred to an earlier lesson with only one or two problems that contained new material. Each lesson added small increments of a concept that was built over several lessons. I tried to change my teaching. Instead of reading the lesson to them from the book or just explaining what the lesson was about as I had always done in the past, I tried to have them read the lesson instructions to themselves before we read it and analyzed the lesson together. I tried to ask questions about what they thought the lesson said to do before I went into the explanation of how to do the procedure that was taught on that day’s lesson. Next, we went over any misconceptions or difficulties they had with the prior day’s lesson, searching for where this was taught in the math textbook or what they could have used from the textbook to help them solve the problem. Then they handed in their homework papers to be checked. The students needed to pre-read the story problems in the lesson to see if there were any problems they wanted to go over in class. The students then practiced the new procedure for the day and finally they had a little time to work on their problems in class.

On the days that the students were engaged in a problem-solving session, I arranged the students in problem-solving groups. I put one very good math student as the leader and then tried to have two proficient team members and one student who might have much difficulty with math in a group. The students then got together in their problem-solving groups and went over any misunderstandings or troubles they had had with the prior lesson. Students then worked together to fix problems where they did not agree. I was the referee and they would ask me to
help them resolve which answer was correct. After about 10 minutes, they handed in their homework for evaluation by the teacher’s aide or me. Then I handed out the problem group activity or problem they were to solve for that day. I then stepped back and let them work using the structured problem-solving form. I was available for questions. Usually students handed in their solutions with the structured problem-solving form (Appendix E) at the end of class. If they needed more time, they could work with their group during study hall. Study hall was supervised by the principal and an aide and was part of the students’ class schedule. Study hall was where students worked on assignments that were given during their classes. At the beginning of the next class period I had the students present their solutions. Finally the problem and its solution would be discussed with the whole group.

In the Saxon book, the first 10 problems were usually word problems, so those were the problems we usually read over together and analyzed in class. Going over these problems in class and working in a group helped the students solve these problems. After practicing solving problems with a group and working through homework or problem presentations, students seemed more confident in their abilities and more inclined to work independently to solve word problems than they were during the first semester.

In working with rectangles, squares, and their properties, I wrote an ill-structured problem (See Appendix I) for the students to solve in their problem-solving groups. The students had to figure the most economical way to enclose a pen for a horse using the least amount of fence around an area of 144 square yards. Students modeled at least four different rectangles, figured the cost of fencing these rectangles, and then selected a rectangle and explained why that shape would be the best choice. After dividing the group up into six groups, I handed out problem sheets and decided that I was not going to read the problem or try to head off
misunderstandings. I was going to try to have the students be independent and work through the problems with their group. I had to purposely start grading papers so that I would not feel like I had to explain it.

Half of the groups found the shapes and figured the cost correctly. Students in the other three groups were confused by the square yards. For some reason, after they found the perimeter of the rectangular shapes, they thought the perimeters were in feet, so they decided to change the perimeter to yards and divided the perimeter by three. The students divided the perimeters by three and then multiplied to find the cost of the fencing. Since the price of the fencing was in dollars per yard, their cost ended up to be much less than it should have been. Therefore, they missed the cost of the fencing even though their perimeters were correct.

When I looked at their problems that day, I did not have a lot of time so I could not figure out what they are done wrong. The next day in class, it seemed much better when I said I could not figure out what was wrong so the students had to analyze what they did and figure out what they had done wrong. One student exclaimed that they had divided by three to change to yards and it was not necessary. Students then were able to change their answers and understand what they did wrong.

The first research question was what happens to students’ problem solving when I had students work in groups with a structured plan involving reading strategies to solve problems? My assertion was that students liked problem solving better and were very confident about working with a group. They willingly filled out the structured problem-solving plan because they were doing it with the people in their group. Students were more eager to work together in groups to do problem solving and they did not even seem to mind that they needed to take more time to use the structured plan.
My first piece of evidence was the student journals written on 2/27/09. One student (Sabrina)\(^1\) wrote in her journal, “I feel good when it comes to working in groups because you have lots of ideas.” Another girl (Lily) wrote, “I like working in a group so we can all work on different parts.” My negative child (Melissa) wrote, “I liked it. It was fun.” And then she added the zinger, “We were not very successful because you gave us hard questions that didn’t make (scence) sic.” I called Melissa my negative child because I noticed on the survey she did for Math in the Middle research in September that she said she did not like math because the teacher yelled all the time. That was the first instance where I noticed that she was putting the blame for her difficulty with mathematics on me. She considered that it was my fault that she was not successful with math. Thus, the comment that she and her group were not very successful was because of my choice of hard problems. With the exception of her journal entry, all of the other students thought their groups were successful.

I noted in my journal that on 2/26/09, the students worked in groups with a structured form to solve Problem 1 on Lesson 80 (See Appendix J). The problem said, “The Jones family had two gallons of milk before breakfast. The family used two quarts of milk during breakfast. How many quarts of milk did the Jones family have after breakfast?” The problem was from the regular lesson, which contains at least 10 short story problems with fewer than three steps to solve the problems. Therefore most groups solved it very quickly. Story problems that have more steps and are not part of the patterns used in the Saxon book are more difficult for the students to solve quickly. However it took the students about 10 minutes to fill out the form. Four out of six groups were able to summarize the problem well, one group wrote a simpler problem and the last group wrote a new problem like the original problem to show that they understood what to do. I

\(^1\) All of the student names are pseudonyms.
was surprised that when I introduced the problem-solving form, students accepted working through it, even though it increased the time they spent on each problem. Because the structured problem-solving form was part of the group work, the group worked together to complete the form.

My third piece of evidence was the problem-solving plan papers collected 2/26/09, where most of the students groups said that they had prior knowledge because they knew some liquid measure and how to convert liquid measure. Their prior knowledge of how many quarts were in a gallon helped them solve the problem. Three of the groups did draw a picture to show what the problem said, while the other three groups just said they could picture the problem in their mind (Appendix J). The groups restated the problem in their own words. The group of Shelly, Carmen, and Grace wrote, “How much milk was left when the Jones (Joneses) was done drinking 2 out of 8 quarts?” Five out of the six groups responded that the first thing they should do to solve the problem was figure out how many quarts are in two gallons. All groups were able to solve the problem about liquid measure.

Another piece of evidence was the problem-solving sessions I had with my Advanced, Proficient, and Progressing students using the problems listed on Appendix H. During the second session my Progressing student was able to read the problem to me, discuss the steps he was planning to do, and correctly solve one of the problems on 4/15/09. See his two examples of work on Appendix K. Notice that he was much more thorough during the second problem-solving session. My advanced student and my proficient student were able to solve problems well both times.

During the interviews I did with students, most expressed the belief that they were more successful at problem solving this year than last year when they were in fifth grade. In a student
interview on 3/19/09, I asked Danny the question, “Has your attitude about working word problems changed during your sixth grade year? Danny answered, “Yes, because I am better – older and learned more stuff.” Twelve other students also indicated during their interviews from 3/19/09 to 4/14/09 that their attitude about working word problems had changed. The following examples were from some of the students’ interviews. John, on 4/14/09, answered, “Yes, cause it’s not just written there, you have to figure what process you do to figure it out.” Shelly, on 4/03/09, answered, “Yes, because I have had more practice.” David, on 3/30/09, said, “I understand them (story problems) a lot more.” Carmen said, “Yes, I don’t get as frustrated,” during her interview on 3/30/09. Three students answered that they did not like word problems and their attitude had not changed. For example, Ted, on 4/14/09 said, “No, cause some of them don’t make sense.” Melissa also expressed displeasure when she did not know what the story problems meant during her interview on 4/03/09. Sabrina, at the beginning of the interview period, on 3/19/09, concluded, “No, I’ve always not liked math.”

In their journals entries for week six on 3/27/09, 12 out of 20 said that the structured form (Appendix E) had improved their work. Leah was one who claimed that her work had improved. See her work on the structured form where she answered all of the questions on the form and her answers showed that she planned out her problem-solving process (Appendix L). Tyler, on 3/27/09, specially wrote, “Yes, the form has improved our work.” All students, except three, wrote in their journal that they saw a change in their problem solving this year. Two of the three students who wrote that they had not seen much change were already good problem-solvers, so perhaps they did not see much of a change. Cortney was one of the students who wrote she had not seen much change. The proof that she was a good problem-solver was her performance in the Math Olympiad problem-solving contests this school year. She placed
Twelve out of 17 students wrote in their journals on 3/19/09 that they liked working in the group because they could discuss the problems and they felt more confident. Ted wrote in an earlier journal on 2/27/09, “I feel like I can do it (problem solve).” Sarah wrote, “I feel like I can get it done. It makes me feel more confident.” Sabrina wrote, “I feel successful in a group.” Melissa wrote, “I feel better because people help me.” Cortney wrote, “I like working in a group better than working alone because you can get somebody else’s opinion.” Reasons for disliking working in a group included feeling left out, feeling like you were doing it all, and preferring to work alone. I noted in my journal on 4/18/09 about what I observed about group problem solving when I wrote, “Students always seem eager to work on story problems in group setting. They like to have the answer figured out before the other groups.” Before when students worked alone, they often felt uncertain and needed my help instead of seeking the help of their peers.

Another piece of evidence was found within the written work that they turned in based on the problems. I saw them being successful as I gave them a problem (Appendix M) from the seventh grade Algebra ½ book on 4/14/09, for them to solve. This was a difficult problem because there was an unknown quantity that students had to find first by finding the area of two regions, adding the areas together, and then using algebraic thinking before they could solve the problem. All the groups were successful in solving the problem. See group work attached as Appendix N. I then used the problem-solving rubric (Appendix F) that I based on a rubric from the Schreyer Institute for Teaching Excellence at Penn State to evaluate their responses. I found that although they were successful in solving the problem, they needed to work on how to communicate what they did to others. Most explained that they had to add the two areas together
to find the area. Others ignored the questions about explaining and just told what they did to get the answer. They did not say why they divided the total area by 6. So, although I could see they understood the concept of area, they did not explain how to find the area of a rectangle or why if one knew one side of the rectangle, one could divide the area by the length of one side to find the missing side.

When I stepped back and looked at what was happening, I observed that most were really confident problem-solvers. They liked to work in a group, and they liked the competitive aspect of trying to solve the problem before the other group. Tyler, in his interview, said, “I like working word problems this year, because I like to be competitive.” They appeared to like the structured form and talking about how to solve a problem in a group setting. On the journal entries for 4/16/09, 2009, 14 out of 19 students answered that they liked working in a group and answered yes to the question, “Have you seen any change by using the structured form with your group?” Lily wrote, “I like working in groups because we can check with everybody. Yes, I get better grades if we work together.”

My second research question was what happened to students’ understanding when they were taught reading strategies for reading mathematics using math-infused literature and story problems about areas of concern for them? Besides enjoying the corniness of the “Sir Cumference” stories, I observed that students had gained in their understanding of geometry terms from hearing stories about Sir Cumference, Lady Di of Ameter, and their son, Radius. I also noted that students had become more aware of reading for understanding when they had a word problem to solve due to the reading strategies they had been taught.

I hoped with this project my students would develop more confidence about discussing math and more confidence in their abilities to explain math to the whole group, especially the
three students that were very negative when writing about math. Both Melissa and Ted complained about really hard problems that did not make sense in their interviews. Melissa said, “No, I don’t like story problems.” One of the interview questions stated, “Did you enjoy working word problems before this school year? Why do you think this was so? Has your attitude about working word problems changed during your 6th grade year?” When Ted was asked the preceding questions on the 4/14/09 interview, he answered, “No, cause some of them don’t make sense. (My attitude is) pretty much the same.” John was a very intelligent student who did not lack for confidence in his abilities, but he was very negative about any help or change I was trying to make. In his journal on 2/16/09, John stated,” I have had not prior trouble with story problems. Today I do story problems in almost the exact same way I did in 4th grade. Don’t get me wrong, there have been plenty new kinds of story problems, but I don’t need any help.”

The first indication that one of the students might have been feeling better about math was in my journal on 3/18/09 when I wrote about Ted, one of my negative guys, who really picked up on the idea of parallel rays of light, which come from a laser. He volunteered to tell the rest of the class what the word “parallel” meant. Earlier in February, when the more advanced students had gone to a special music event, he had been one of the students who was totally confused about parallel, perpendicular, and polygons on that day. He was still confused when I gave the geometry pre-test the next day. On that first geometry test (Appendix D), he scored 66% because he was very confused about geometry terms, such as parallel and perpendicular, circumference and diameter. Further evidence indicated that he understood geometry terms much better when he scored 95% on his post-test. On his post-test, he was able to give the correct definition and draw and label a picture of the terms parallel, perpendicular, circumference, and diameter.
Not only did students like hearing the “Sir Cumference” stories, they also learned geometry terms and relationships and wrote in their journals about these relationships. On 3/19/09, I interviewed four students and asked questions about the math-infused literature. In the interview, Nancy indicated that she really liked the math-infused literature of the “Sir Cumference” book, saying, “There should be a book for every lesson. I liked the Di names and Geo and Sym of Metry.”

The students’ journals explained about the relationship between *Sir Cumference and the Sword in the Cone* and their work with platonic solids on Monday, 3/16/09. Twelve students were able to state the relationship between the faces, vertices, edges and the number two in their journals. Six other students were able to tell what the faces, vertices, and edges were. One student noted that they had folded paper nets into different polyhedron, just like Vertex and Radius did in the “Sir Cumference” book. Two students noted that the cone and the cylinder did not have the relationship of two, like the other platonic solids. See Appendix O for student journals that showed the relationship of \((\text{Faces} + \text{Vertices}) - 2 = \text{Edges}\).

Further proof that students had learned the geometric terms came from the geometric term test (Appendix D) I administered in February and the same test I administered on 4/27/09. On the first test, students missed an average of 5.4 terms out of 19. Most of the confusion came from the terms parallel, perpendicular, radius, diameter, and circumference. On the last test, students missed an average of 1.75 terms out of 19. Students had learned these terms. The “Sir Cumference” books explained these terms with special names and pictures. The pair of Ell dragons that spanned the moat showed the meaning of the word parallel in *Sir Cumference and the Great Knight of Angleland*. Lady Di of Ameter’s height and extended arm reached across the diameter of the large tree that was found for the round table used by King Arthur and his knights.
in *Sir Cumference and the Round Table*. Only one student showed confusion over the terms of circumference, diameter, and radius.

Students seemed to especially like the strategy of visualizing the story problem and relating it to their life, and continued to realize that slowing down and rereading the questions carefully would help them solve the problem. On the post-survey, 17 out of 20 students answered that they tried to visualize the story problems as they read them compared to 14 students on the first survey. From the first survey to the second survey the number of students who answered that they agreed with slowing down and reading the story over did not change very much. Fourteen out of 20 students answered that they agreed with the statement on the survey, “I must slow down when I read my math textbook.” Fifteen of the 20 students agreed that it was OK to read a story problem over several times.

I noted this observation in my journal on 4/18/09: “I think most of the students are using visualization, re-reading the question and slowing down to think about the question.” The students showed the use of visualization on their structured problem-solving form, because they almost always filled out the picture question or they would say that they visualized the problem in their head. Another piece of evidence was a student journal entry by Lily. Lily went a step further in visualizing than some students as she wrote in her Week 6 journal on 3/27/09, “I can picture that I am in the story or picture something I like.” She was not only picturing the story, but also she was putting herself into the story.

According to the post-survey, students believed that they could recognize patterns in story problems. “Patterns,” said 17 out of 20 students, “will help me solve the story problems.” That was an increase of five students from the pre-survey. One more student answered positively that they could restate the story problems in their own words. I noted the use of patterns on the
structured problem-solving form as students wrote EG meaning Equal Group Pattern, Some and Some More, and Some Went Away Patterns. Because of the problem-solving form, they were required to summarize the problem in their own words. On work done on the Algebra ½ problem (Appendix M) 19 out of 20 rewrote the problem correctly. Nancy wrote, “The outside picture frame shape is 36 square units. The inside rectangle is 24 square units. What is the length of x?” Melissa wrote, “The colored part is area 36 sq units the white part is 24 sq units. How long is the x part?” See Appendix P for examples of how three different students had restated the problem in their own words.

My final research question involved all of the prior questions and asked for an overall assessment of what I thought was happening. The final question was what happened to my classroom when I had students work in structured groups to do problem solving, when I taught reading strategies for mathematics, and when students wrote in journals after problem solving?

I thought that my students and I were analyzing what was happening with certain problems and took more care to think about what strategies they were using to answer certain problems, but they still made mistakes in reading and sometimes they preferred to have someone read or explain what to do rather than figuring out what to do on their own. From conducting interviews, reading journal entries and assessing problem-solving forms, students seemed to like working in structured groups and the math-infused literature, but it took more than just teaching a few reading strategies to make students more independent. It took time for students to gain confidence in their own ability and to have the courage to go ahead and solve problems on their own.

My first piece of evidence that students had gained confidence in their ability to solve story problems was the Math Olympiad Test on 3/05/09. I gave them their last Math Olympiad
Test for the year with a copy of the problem-solving sheet to remind them of the work that they had done in groups with a structured plan. They solved some fairly complex problems and followed a plan. They answered questions about what prior knowledge they had and some of the forms showed visualization of problems. This showed that using the structured plan helped their problem solving. I have included Grace’s and Sarah’s problem-solving form (Appendix Q). On this test Sarah was able to get 4 out of 5 questions correct and Grace was able to get 3 questions correct. Grace’s average number of questions correct on the prior 4 tests was 2 and Sarah’s was 1.75. I chose these two students work because of their completed problem-solving form. Of the 20 students who took the last test, 12 had a higher score than their average, and three students stayed the same. Five students did not do as well.

From my own experience in Math in the Middle classes, we had learned to work together in groups and as we worked more problems and were successful, we gained more confidence in our abilities. At the beginning of Math in the Middle classes, I had no confidence in my ability to find an equation to solve a word problem. Since working with groups and seeing how others found equations, I have learned to write equations that work.

While students seemed more confident about solving story problems, the test I gave them on Thursday before we left for the State Basketball Tournament showed misunderstandings in reading the word problems and in working the fraction problems. However, when I looked back and analyzed the problems in my journal, I found that not everyone misunderstood the same problem. Two out of 20 students misread, “Write the standard number for (4 X 10) + 3 X 1/10.” Three out of 20 students did not reduce the ratio or wanted to change the ratio 4/3 to 1 and 1/3. The procedure for solving multiplication and division of fractions was still difficult for some students. They seemed to have lots of trouble with the four fraction problems on the test, but
after looking at it again, I realized out of the 20 students and the four fraction problems, only 10 problems were actually missed. When the students analyzed the problems they missed in their journal, five students wrote that on the 17B test they had misread the questions that they missed on the test. Students misread questions even after working on reading strategies. I noted in my journal on March 11, 2009, “What a wasted week! Basketball was utmost on everyone’s mind.”

When the problem was particularly difficult, students still liked the problem read to them and explained part by part. An account from my journal told about when students wanted me to read a particular difficult Mathcounts problem that we were doing in relation to the Mathcounts Awareness Week at our school. The Mathcounts team was going to state competition on March 21, and I wanted other students to be aware of the difficult problems they would be encountering at the competition. Each day of that week, I had printed off a Mathcounts problem taken from this year’s competition. Fifth graders through seniors and staff members had a chance to solve the problem, put their answer in a jar, and if their correct answer was drawn, win a candy bar and a pop.

The problem I wrote about was a particularly hard problem about a game of Frood. This question came from the 2009 School Test for Mathcounts. Dropping the Froods meant that you added the number of Froods like $1+2+3+4+5 = 15$ and eating the number of Froods meant multiplying the number of Froods by 10. They were to find when the number obtained from dropping the Froods became larger than the number obtained from eating the Froods. I explained how they could read it by taking it step by step and changing the word Frood to something like French Fries. They were then able to proceed to solve the problem, showing that there were times when students needed reassurance and help in solving a problem. Unfortunately, I did not
keep these Frood problems because they were put into a jar from which I would draw the winner out of for that day. After drawing the winner, I threw the problems away.

When I interviewed the two students, Danny and Tom, on 3/19/09, they again said that they learned best when my aide or I explained the problem step-by-step slowly. Danny answered the question, “What do you like best about math?” and said, “When you and Mrs. Watson explain it.” Shelly also answered, “How the teacher explains it.” She continued to say that what makes math easy for her is the way you (Mrs. Steinbrink) teach it. So, even as I had encouraged students to use reading strategies, they did not always remember to use the strategies. Sometimes they did not even remember what the strategies were, and at other times, they would prefer that someone simply explained the problem to them.

After group activities and problem-solving sessions, the students wrote in their journals about the activity. The activities were written by me to practice a concept that was recently introduced in the Saxon lessons. At least once a week, they analyzed how they had performed during the activity and what they had learned. They wrote the new concepts for the activity in their own words. Journaling was another way that students could practice using their mathematical register. Journaling also helped them formulate what was the essence of the lesson and what was important to remember. Their journaling also helped me assess what the students needed next to advance in their understanding of concepts about geometry and mathematics.

Reading the students’ journals as well as interviewing the students gave me insight into what the students were thinking. As a teacher, I was able to take direction from statements found in the journals of the students. I had found that students felt that doing 30 problems every day was too much. Sabrina, a student that had moved here this year from Oklahoma, was very insistent in her interview that she did not have enough time to do 30 problems. After I started
giving them only 15 problems, all students answered in Journal Week 8 that they like having less problems to do. They felt they had more time to think about the problems and so it was easier. On 4/16/09 on Journal Week 8, I asked the question, “How do you feel about only doing the odd or even problems for the math assignment?” Of course, 18 out of 20 students answered that they liked it much better. Cortney wrote, “I like it because it gives you more room to do your (sic) work and less homework at night.” On my grade sheets, there is evidence of the reduced number of problems on Lessons from 95 to Lesson 104.

To see what happened to the students’ percentage grades starting with Lessons 93 and 94, which were regular lessons, and comparing the percentages from the reduced number of problem lessons where only odd or even problems were done, I found the percentage that students scored on each type of lesson. Students may have not perceived that they had a lower percentage because their papers were marked with the number missed and not the percentage. The percentage for the regular lessons was 86.1%, while the percentage for the reduced number lessons was 81.39%. One of the reasons this may have happened was that students might have finished the reduced number of problems in study hall and not taken it home where their parents were used to going over their lessons at night. For example, Melissa had an average of 86.5% on the whole lessons and an average of 75.25% on the lessons with only odd or even problems. Her mother usually checked over her lesson each night when she had 30 problems to do.

In my journal, I had expressed frustration that the students were doing very poorly on their lessons and some had forgotten the decimal rules for division. The Saxon book was a very programmed book, with each lesson building on the next lesson, and I was afraid that some of the group problem-solving sessions that were not part of the Saxon textbook, had disrupted the flow of learning. Sixth graders had to be able to compute fraction, decimal, percent, and
proportion problems and use those concepts in solving word problems with fractions, decimals, percents, and proportions. Those procedures were needed to figure interest, measurements, changing recipes, and using chemicals and oil. The procedures of working with fractions and decimals seemed to be slipping from their minds as we had two days of testing for the Nebraska State Standards, testing for ITBS, and a couple of days where they had no study hall and consequently rushed through their daily assignment and did very poorly.

In order to try to help the situation, I had to institute only doing the odd problems instead of doing the whole lesson of 30 problems. I had to be absent two days for various reasons and we had two four-day weeks due to Easter vacation. I planned one day a week for problem-solving group work to work on geometry, proportion, percent, probability, and a day to discuss what happened with the group work. I chose problems that included the concepts that were being taught in the Saxon lessons. With only two days to practice procedures with them and to try to correct incorrect procedures they were using to do problems with fractions, decimals, and percents, I was frustrated. On Tuesdays, we had Spanish for part of the math period and I also had to work around that.

I had Sabrina come in after school because she had still missed 8.5 questions out of 15. When Sabrina came in after school, she again mentioned how she did not really like math. What was discouraging was that most of her low scores came from working carelessly. I knew from Sabrina’s work on her last four tests that she knew how to compute fractions and decimals and how to change fractions, decimals, and percents from one form to another. Out of the 40 decimal, fraction, or percent questions on the last four tests, she had only missed three problems. I talked to her about faking it, that was acting as if she liked math until she could really begin to like math as recommended by D. McKellar in her book *Math Doesn’t Suck-How to Survive Middle*
School Math Without Losing Your Mind or Breaking a Nail (McKellar, 2007). Surprisingly, her papers had improved after that. She even had a 100% on her Test after Lesson 100. So the major adjustment I tried to make, giving them only the odd problems, had created a lot of stress for me, because the Saxon book stated that students should do every problem in each lesson. The authors of Saxon Math believed that students had to have enough practice to be able to remember procedures that they will need for the rest of their lives. Saxon wrote in the introduction to his 1981 algebra textbook that “repetition is necessary to permit all students to master all of the concepts” (p.1). Then the application of concepts was needed for a long time to ensure retention.

During the week of 4/18/09, we did finally have some time to talk about procedures and I thought the students’ understanding of fraction, decimal, and percent problems was better. On the test after Lesson 100, Melissa was the only student who missed changing 5/8 into the decimal number .625. She wrote her answer as 625% showing she either did not understand percent or she was being careless. Seventeen out of 20 students missed Question 2, which told the students to write 0.4 as a reduced common fraction. Tyler missed it because he put 40%, clearly misreading what the question asked him to do. David wrote 1/25 because he thought it said 0.04 instead of 0.4, and Caden gave the answer as 1/5. The class average score on the test was 88.125%, which was acceptable to me. Ted, Melissa, and Sabrina passed the test with 90%, 78%, and 100% respectively.

It was difficult to change from a traditional classroom where the teacher spent most of the time explaining the concepts and procedures in front of the class to a classroom where students took on more responsibility for learning. For me as a teacher, I needed to hear myself explain procedures and concepts to the class and get feedback from them immediately as they worked the problem on their individual white boards, or answered my questions. It was hard not to
explain how to do interesting problems to them because I wanted everyone to see how special the problem was and what new concept was there. It was hard to watch students explain the problems when they did a poor job of explaining because I feared some students would become even more confused. Some students did have difficulty reading and that made it hard for them to be independent. In this class of sixth graders, I had two students whose IEPs said that questions on tests should be read to them. I also had one student whose parents had refused services, such as Title 1, for him and consequently, he found reading independently very difficult.

Looking back over the journal entries, I have discovered the following things about my teaching. I had been in a very traditional role when introducing new concepts, which was when I explained the concepts to students, instead of asking them to figure out what was new or different. Students had found that the best way to succeed in my class was by paying attention and working hard. Although the students worked in groups at various times during the school year, they still had problems working effectively in groups because they relied on the teacher to set up each task they did and often did not think for themselves very well.

The evidence of this produced a very unsuccessful lesson that I wrote about in my journal. I wrote about my frustration, “Students really disappointed me today and I disappointed myself when the lesson went so poorly.” The students went to the science room to work on measuring round objects. The worksheet (Appendix R) that they used had directions for measuring circumference by first using string and then a tape measure. I had assigned the students to groups of three or four students and they were to measure the diameter of a circular object with a piece of string. Then they would cut that piece of string and used it to measure around the circumference of the round circular object. The students were to record how many times it took the piece of string to go around the whole circumference.
The next task they were to do was to use a tape measure to measure the circumference, then measure the diameter and then divide the circumference by the diameter using a calculator to see what the ratio of the circumference was to the diameter. Because we were rushed for time, I had them only do about three of the objects using the string, and then we jumped to the other section where they were measuring with the tape measure. The students were very loud and raced around trying to find round objects to measure. They were very inaccurate in their measurements, so there were some groups who never got 3.14 or even close to that number for their ratio.

When they wrote in their journals later about what went wrong, one person mentioned it would have been better if I had provided them with the items that they would have had to measure. That was right, it would have better in that they might have been quieter because they would not have been running around, but they would not have learned anything about picking objects to use, or thinking about getting a variety of objects to best illustrate the problem.

As I conducted the interviews with the students from 3/19/09 to 4/14/09, I asked the question, “What would you tell a new student about what it takes to be successful in this math class?” At first I was quite pleased when students in their interviews told me, “Pay attention and work hard.” Then I started thinking, was that what was important to be a good math student? Dr. Fowler had asked us that question in the fall semester class. None of my students had answered, “Think, be a good problem solver, work independently to find an answer, share math knowledge with others, explain thoroughly or write out problems with good explanations.” The NCTM standards of communication, problem solving, and representation had similar goals for students. Students in my class showed their understanding that the teacher ran the show and valued paying attention more than anything else. So that students would know that I valued these standards of
communication, problem solving, and representation, I would need to talk about these standards and their results as a desirable goal for students. Problem solutions presented by students should be celebrated in my classroom. As a teacher, I would need to show appreciation for independent work and thinking.

In the future, I would want my students to pay attention, but pay attention to other things than just the teacher. I would want them to attend to the details of procedures, to what other students were saying about the problems, and to their own thought processes. These were all important to becoming a better learner of mathematics. Paying attention to these things meant that the students would actually have to think through problems and procedures, which was difficult to do. I would have to accept that the process of students arriving at their own conclusions might be messy. I would have to spend more time hearing and analyzing those conclusions.

Students still preferred asking for help when word problems were hard. It was interesting that the number of students who on the survey answered the question “when I don’t understand a mathematics assignment I….” with the answer ask the teacher or someone did change some, but not all that much. On the first survey almost everyone answered what he or she would do when they did not understand a mathematics assignment with the answer, “Ask a question, ask the teacher, friend, or parent.” On the second survey, only 10 students answered with ask someone or the teacher and four students actually suggested reading in the book. Others had answered ask the teacher coupled with another strategy. One student said, “I use my math book and break it all down.” Maybe there was a glimmer of hope that students would become more independent.
Conclusions

My study on reading and mathematics investigated math-infused literature and word problems, reading strategies, and a structured group setting for my sixth graders to use. My study extended the literature on structured reading strategies from children with learning disabilities or second language learners to a whole heterogeneous classroom. I thought it was important to see how changing the way I approached reading mathematics problems would impact student problem solving. I looked for observable behaviors that sixth graders used with problem solving. I found ways that students could use structured group work to help them learn individual self-regulated techniques for problem solving. I used math-infused literature and ill-structured math problems to interest students in problem solving. My study showed how students in sixth grade reacted to the “Sir Cumference” books. My study showed that an experienced teacher with a set curriculum could add new problem-solving tasks and group structure to improve her teaching.

Finally, I felt that most students were able to handle reading and solving story problems in a confident manner. “Students should view the difficulty of complex mathematical investigations as a worthwhile challenge rather than as an excuse to give up. Even when a mathematical task is difficult, it can be engaging and rewarding” (NCTM, 2000, p. 21). This quote was the essence of the value of doing Habits of the Mind problems, Math Olympiad problems and Mathcounts problems. Even when the problems were not solved correctly, concepts and ideas had been recalled and tested.

With new reading strategies and structured group problem solving incorporated into my curriculum, I felt successful as a teacher when students seemed eager to solve new problems, even though the problems were difficult problems. I noticed that 14 students on the journal entries from 3/27/09 indicated that the reading strategies were helping them read word problems.
Consequently they were more able to solve those word problems. Ted who had difficulty reading wrote, “It (Reading strategies) helpes(sic) me get it right. Another one of the students who had difficulty with math wrote, “They give me sort of a second spin.” Lilly wrote, “I like the reading strategies because they don’t hurt my brain as much.” Bill wrote, “The reading strategies make a big difference.” See Appendix S for his journal entry, which showed an example of the confidence the students felt because of group work and reading strategies. Also on Appendix T Carmen indicated how she would use the reading strategies for the ITBS testing.

Since this study by Lowery and Adams (2006) was conducted before students had instruction in reading mathematics in a trade book and in a textbook, my study showed how students benefited by instruction in reading techniques. I was not able to use two to four weeks for one problem as Leader and Middleton (2004) suggested, but I did use some of their principles in choosing problems to interest the students. Some of the problems did have multiple solutions, and I encouraged my students to find and support more than one solution for the problems they did. The study by McDuffie & Mather (2006) seemed ideal and just exactly what I would have liked to be able to do. While the study by McDuffie & Mather (2006) showed how a teacher changed with the help of a mentor, my study did not have the support of a mentor that could supply materials and visit with me daily about my role in the classroom. My study showed how a teacher without a mentor changed in her teaching and planning of lessons.

Both of the teachers in the article by Reeder et al. (2006) had classrooms like the classroom I tried to create. My study focused on sixth graders instead of second graders or eighth graders, so my study showed how a teacher of sixth graders could change as her ideas of teaching changed. I tried to provide my sixth grade students with interesting problems that would engage them in solving word problems independently with good reading, writing, and
communication skills. My study extended the literature of observable results when choosing appropriate and interesting word problems that interested and engaged students at the sixth grade level. My selection of ill-structured problems and my students’ response to these problems provided examples of how students reacted to ill-structured problems, which was not apparent in the literature I reviewed.

I observed that students improved in problem solving as a result of working in a group with a structured plan for solving the problem. They were able to use the reading strategies suggested by Carter and Dean (2006) of activating prior knowledge, summarizing, and learning vocabulary. The students activated prior knowledge and summarization with the use of the structured problem solving form. The structured problem-solving plan also had a place for the students to reflect on the problems that they had solved as suggested by Capraro & Joffrion, (2006). Working in small groups of three or four students, the students practiced “clarifying, questioning, summarizing, and planning” how to solve the word problem (van Garderen, 2006).

From the results of the geometry test, I had evidence they learned geometry terms well from listening and using the math-infused literature in the “Sir Cumference” stories to bridge understanding of new concepts. Capraro & Capraro (2006) had similar findings when they stated, “The students using the math-infused literature showed fluency with geometry vocabulary, demonstrated flexibility in the application of geometry concepts, explained formulae with rich descriptions, and out performed the non-story group on geometry ability” (p. 21).

I tried to create or find word problems or activities that would enhance and reinforce concepts taught in the Saxon textbook. In following the Saxon book, I was like the teacher described in the article by McDuffie and Mather (2006) who had a very traditional, district curriculum to follow. I tried to find problems from outside sources and I began to choose
problems specific to my students’ instructional needs based on what I saw the students do
together with what they wrote in their journals and what I wrote in mine. In McDuffie and
Mather’s case study, the teacher learned to make problems work for her objectives and not let the
problems decide the course of her instruction. I think I had an introduction into that process of
choosing problems based on the students’ needs.

In cleaning out bookshelves at my house, I found a copy of *Teaching Mathematics to the
New Standards – Relearning the Dance* (Heaton, 2000). I bought it when I first began teaching
math about 10 years ago. At that time I had all the fifth, sixth, seventh, and eighth grade
mathematics classes with the exception of the eighth graders who took Algebra 1. In reading
Heaton’s book, I realized I was very proficient at the dance that my students and I were used to,
that is, I would introduced a new concept in a lesson, the students explored that concept as they
drew pictures, did practice and questions that I set up. Then they would do the problems
independently. The next day students asked questions, we checked the papers and went on to the
next lesson. We often had some really fun discussions and the students’ questioning and my
searching for a way to show them what to do brought many new ideas to my mind.

I was not very proficient with this new dance in which they were supposed to learn by
being more independent and figuring more concepts out by themselves. I went to immediate
frustration when I realized students were not measuring the circumference with the tape
measures very precisely. They were supposed to be able to divide the measure of circumference
by the diameter and get a number close to 3.14. Because they were measuring so poorly, they
ended the lesson with no valid conclusions and the whole lesson time was wasted. Heaton had a
similar experience with measuring cans to make a label for them. She ended up working on the
lesson for a week. I did not have a week.
I have learned that the students’ journaling gave me a look into what students were thinking that I did not have before. I especially used the journaling after the disastrous lesson on using string to measure to find how many diameters were in the circumference of a circle to help me understand the unsuccessful lesson. Danny thought the students were being loud because they were having fun. Some suggestions were to stop the lesson and have just specific items to measure. Other students suggested that students could lose recess or have their name written on the board. Then when we reviewed the lesson and the measuring mistakes they had made, they were much more attuned to what their responsibility in the lesson’s failure had been. They were also able to solve the problem at the end of the class that I put on the Smartboard which said, “If you have a circular lake and you want to know the distance across the lake and you don’t have a boat to take you across and it’s too far to swim, how would you find the distance across the lake.”

While this action research project helped me try new practices, I definitely found that I have a long way to go in creating the classroom that I would like to have. I found that having the students write in their journals was a dance step I would continue. I especially liked the way the students used the structured problem-solving form and the reading strategies to help them solve word problems. Working together in problem-solving groups helped the students be more confident. I am going to have to work on continuing the new dance and continue to practice the new steps.

**Implications**

What are the implications of what I will do in the future based on my research project? The first thing I will do is to continue to look for ways to make my students more independent. I will teach the reading strategies immediately when we start class in the fall. With each lesson, I
will remind them of looking at the problem and understanding it first before they try to solve it. I will work with them on the summarization of word problems, so that they can use this tool to help themselves understand the problem. I will definitely look for more word problems that fit concepts I want the students to learn, and I will plan more time for them to work in groups with the story problems I have created or found.

I found that having students keep journals was a great way to find out what is going on with students. I want to encourage journal writing about concepts, but also about procedures that we use in math class. Journaling will help students remember concepts, mathematical procedures, and improve learning for all students. I want to continue to interview selected students individually to watch their problem-solving strategies and to find out how they look at themselves and their math ability. To see their thought processes and how they handled themselves when they were stuck on a problem suggested ways for me to help them with problem solving.

I will continue to read the “Sir Cumference” stories and look for other math-infused literature since that seemed to really help the students remember geometric concepts. I will have as many books available for students to read about mathematics as I can find. I would like students to tackle the assignment of writing their own math-infused story with concepts that they chose like decimals, money, or fractions.

I will assign fewer problems for each lesson in the Saxon book. Perhaps with less outside work to do, I can plan which problems are the most valuable to do out of the 30 problems in the Saxon Lesson. I will continue to have students work in groups on story problems from the lesson, but I will try to find other interesting problems for students to solve in their groups.
The two forms I created will be valuable to use in the future. I will continue to give them the structured problem-solving form to use for group work, and then also to use independently. The problem-solving rubric that shows five levels of ratings of how they solved the problem will be especially important. The rubric will inform students about their problem solving and how they can improve that problem solving. I want to emphasize that students write down how they solved the problem, so that others can understand the method, not just the answer.

I am thinking about the changes that I made in my classroom this year, the changes that I want to make next year, and the changes that need to be continued. Success with reading strategies and increases in problem solving ability make these changes worthwhile. When I saw that the changes had made students more confident and eager to solve word problems, I found it easy to continue with my plans to change my classroom. As the students expressed confidence in their abilities to solve work problems, I noticed that I felt more confident too. The students and I were learning a new dance routine.
References


Appendix A

Student Survey

5 = Strongly agree  4 = Agree  3 = Don’t know  2 = Disagree  1 = Strongly disagree

Circle the number that best represents your opinion.

1. I understand what I read in my math textbook.
   5  4  3  2  1

2. I use the glossary or dictionary as I read my math textbook.
   5  4  3  2  1

3. I try to visualize (picture) story problems as I read them.
   5  4  3  2  1

4. I must slow down when I read my math textbook.
   5  4  3  2  1

5. It is O.K. to read a story problem over several times.
   5  4  3  2  1

6. I recognize patterns in story problems to help me solve them.
   5  4  3  2  1

7. I can restate story problems I read in my own words.
   5  4  3  2  1

8. Reading my textbook helps me understand new concepts in math.
   5  4  3  2  1

Answer the following questions with a short answer.

9. What helps me most in understanding math problems is…
10. When I don’t understand a mathematics assignment I ……

11. I can improve the way I read math by ……….

12. I like to read story problems when ……………
Appendix B

Journal Prompts for Students by Geri Steinbrink

Week 1: What strategies did Mrs. Steinbrink introduce for reading a math word problem? Was I able to visualize the problem? Did I understand what I was supposed to do? Did I see any difference in how successful the group was in solving the problem?

Week 2: How did you feel about working in a problem-solving group with a structured plan? What would you do different next time? How successful were you in solving the problem?

Week 3: What did you think of the story I read about Sir Cumference and the First Round Table? How did your group find the best shape for a pasture to have the most efficient use of the fencing? Was your group successful in finding the best shape for the pasture? Is there any similarity in the way you found the answer and the way the answer to the King’s table problem was found in the book?

Week 4: Summarize what you were supposed to do as you conducted the survey. Describe any misunderstandings you experienced conducting the survey? Where did your group experience problems? How could you improve your approach to a problem next time?

Week 5: What is the relationship between our Investigation of Platonic Solids and Lesson 90 in our math book to the book Sir Cumference and the Sword in the Cone? What did you learn about edges, vertices, and faces? Please tell me in your own words what you learned about platonic solids.

Week 6: How are the reading strategies helping you? How do you feel when I ask you to do a story problem independently? How do you feel when I ask you to do a story problem with a group? Have you noticed any improvement in your problem solving ability since we have use the structured problem-solving form?

Week 7: How are radius, diameter, and circumference related? Tell me about your plan for finding the largest tree and measuring it with only a string and a meter or yardstick. What similarities do you see between Sir Cumference and the dragon of Pi and your search for the largest tree in Gosper or Furnas County?
Week 7: Second Journal  I don’t think the lesson with the measurement of pi went well yesterday. What should I have done differently so that students would have been serious about measurement? What should you have done yesterday to make the lesson more successful?

Week 8: What reading strategies can you use when reading a mathematics story problem? What do you think about your ability to solve word problems in a group? Have you seen any change by using the structure form with your group? What do you think about your ability to solve word problems on your own? Have you seen any change this year (2009)? What do you think about the Sir Cumference stories? How do you feel about only doing the odd or even problems for the math assignment?

Week 9: What geometry concepts did we read about in Sir Cumference and the Great Knight of Angleland? Describe the building roofs that are in Angleland. What is a protractor? How did Radius use his protractor? What can a protractor tell you about a triangle? What do you think has happened to your understanding of angles and geometry terms when we have read the Sir Cumference books?
Appendix C

Journal Prompts for Teacher

Week 1: What strategies for reading did I introduce to the students? How did they react? How did I feel about their efforts to start to use the reading strategies?

Week 2: When I introduced the structured form for Problem solving, how did students react? Did I feel the students used the form effectively? What do I need to change?

Week 3: How did students react to the reading of the math-infused literature entitled *Sir Cumference and the First Round Table*? How did students do when solving the problem about finding the best shape for a pasture? Was I able to let students work in groups to solve the problem without telling them what to do?

Week 4: How did students respond to story problems involving fractions and percents in which they conducted a survey, predicted outcomes, and produced circle graphs to show results using the structured group strategies? Were students able to read the story problem involving surveys and use the structured form for problem solving by using the reading strategies taught?

Week 5: Did students see the relationship between the math-infused literature *Sir Cumference and the Sword in the Cone* and the Lesson 89, Lesson 90 and the Investigation on Platonic Solids? Did the reading of the book enhance their understanding of the lesson? Were the students able to read the directions for completing the platonic solids and solve the associated story problems? Did the students use the terms vertices, edges, and faces with meaning?

Week 6: How did students react to *Sir Cumference and the Dragon of Pi*? What do I notice about the students’ work? Am I able to have confidence in the students’ ability to read the instructions for finding the largest tree in Furnas or Gosper County and the radius, diameter, and circumference of that tree?

Week 7: How are students using strategies for reading math and the problem solving structured form? How are students using reading strategies to read about probability and chance in their mathematics textbook? What do I notice about the student’s work?
Week 8: What is going on with the students this week? What have I found out from the surveys and interviews that I have done?

Week 9: How does the reading of *Sir Cumference and the Great Knight of Angleland* help students learn about using a protractor? How is the student’s knowledge changing?
Appendix D

Geometry Pretest and Posttest

Date ____________

Name ________________

Directions: Write a definition and then make a drawing and label part.

1. Line
2. Circle
3. Polygon
4. Line Segment
5. Ray
6. Pentagon
7. Diameter
8. Radius
9. Circumference
10. Volume
11. Perpendicular Lines
12. Parallel Lines
13. Oblique Intersecting Lines
14. Vertical Line
15. Horizontal Line
16. Perimeter
17. Cube

18. Rectangle

19. Plane
Appendix E

Story Problem Reading and Solving Form by Geri Steinbrink

Names:__________________________________________________________

1. Understand the Problem.
   a. Can I picture or visualize the problem? Show what you see with a picture or model.
   b. What background knowledge do I have about this problem?
   c. What new words or terms do I need to know to solve the problem?
   d. Have I ever solved a similar problem?
   e. Restate the problem in my own words._______________________________________________________
      _______________________________________________________________________________
      _______________________________________________________________________________
      _______________________________________________________________________________
      _______________________________________________________________________________
      _______________________________________________________________________________

2. Plan the Problem
   a. What should you do first? Is there a simpler problem I have to solve first?
   b. What operations should you use?
3. Follow your plan and check your steps. Write your problem here and work it out. Show checking of your solution.

4. Reflect about your problem solution.
   a. Is my answer reasonable?

   b. Can I check my answer to see if my computation is correct?

   c. Is there another or different way to solve this problem?
Appendix F

Problem Solving Rubric by Geri Steinbrink Part of this rubric is from Schreyer Institute for Teaching Excellence Penn State.

Problem Solving Rubric by Geri Steinbrink

4
Response is characterized by all of the following:

The student selects and implements concepts and procedures that are relevant to this problem and needed to solve this problem.

The student shows evidence of executing a plan and checking steps along the way.

The student shows all work necessary to solve the problem.

The solution and all relevant work are correct.

3
The student selects appropriate procedures/strategies to solve this problem: however, the response/solution is not entirely correct because one of the following happens:

There is evidence the student has a misconception or has failed to consider a relevant concept needed to solve the problem correctly.

The student shows evidence of some planning, but there appears to be no order or checking along the way.

The student shows some work, but some steps are not explained.

The response/solution is generally correct; however, from the information given it is not entirely clear how the student got the response.

2
The student selects appropriate procedures/strategies, however there are some of the following situations that make the response solution not correct.

There is evidence that the student has several misconceptions or has failed to use some relevant concepts to solve the problem.

The student has left out relevant information and variables from the problem.

The student did not carry out the plan far enough to arrive at a solution.
Work is sketchy with no explanation or writing out of the problem.

If the response/solution is correct, there is no evidence to show how the student arrived at the answer.

1
An incomplete and/or incorrect response/solution is provided evidencing an attempt to solve the problem. In addition,

The student did consider some of the variables in this problem.

The student did select a plan, but it was an incorrect plan.

The student appears to understand some concepts related to the problem.

0
Response is characterized by the following:

It is blank.

An incorrect solution and response are shown and no other information is given.

The student appears to have no concept of how to solve the problem.
Appendix G

SAMPLE Student Interview Questions

Student interviews will be focused on a subset of these questions.

1. How much time on average do you spend on homework assignments?
2. What do you think is the purpose of math homework?
3. Do you like doing homework presentations? Why or why not?
4. What does it look like when you justify your answers on a homework assignment?
5. What are the benefits of justifying your answers on your homework assignments, if any?
6. How successful do you feel about using Math skills in and out of class? Give an example of how you use Math outside of class.
7. What do you think about when your teacher asks questions during Math class?
8. What do you like best about Math? What do you like least about Math?
9. What makes math easy or difficult for you?
   - Have you ever had a really bad experience with math? If so, what happened?
   - What could teachers do to help students with in math?
10. When working a word problem, do you think you know the meaning of most of the vocabulary words in each problem? Please give some examples.
11. Why is it important to know the meanings of vocabulary words you see in math?
12. Did you enjoy working word problems before this school year? Why do you think this was the case?
13. Has your attitude about working word problems changed during your 5th grade year?
14. This semester I have changed some of my teaching practices. What advice would you give me about continuing these changes next year?
15. What would you tell someone who is new to our class what it takes to be successful in this math class?
16. I would like you to work on this problem, saying aloud whatever it is you are thinking as you work through the problem. I especially want to hear you talk about how you decide what to do to solve the problem.

   Emma is saving money to buy a bike that costs $72. She wants to buy the bike after saving the same amount of money each week for 6 weeks. How much money does she need to save each week?

17. I would like you to write out a solution to this problem, trying to write down all your steps and explain what you are thinking. Afterwards, I’ll ask you how you decided what to do to solve this problem.

   The ratio of boys to girls in a school is 5:4. If there are 180 students, how many girls are there?

18. Is there anything you want to know from me?
19. Is there anything else I should know about you to better understand your problem solving in math or your general math experience?
Appendix H

Story problems for student interviews Progressing, Proficient and Advanced.

I would like you to pick two of these problems to work on, saying aloud whatever it is you are thinking as you work through the problems. I especially want to hear you talk about how you decide what to do to solve the problem. I would also like to know why you picked the two problems you picked.

1. Albert baked five dozen cookies and gave away 7/12 of them. Then how many cookies were left?

2. What is the quotient when the decimal number ten and six tenths is divided by four hundredths?

3. Robert packed boxes that were 1 foot long, 1 foot wide, and 1 foot high into a larger box that was 5 feet long, 4 feet wide, and 3 feet high.
   a. How many boxes could be packed on the bottom layer of the larger box?
   b. Altogether, how many small boxes could be packed in the larger box?

4. The cost to place a telephone call to Tokyo was $1.50 for the first minute plus $1.00 for each additional minute. What was the cost of a 5-minute phone call?

5. Bianca poured four cups of milk from a full half-gallon container. Then how many cups of milk were left in the container?

6. Sue was thinking of a number between 40 and 50 that is a multiple of 3 and 4. Of what number was she thinking?
Appendix I

Pen Problem  
Names:

A. You must enclose 144 square yards of pasture to feed your horse. You want to use the shape that would use the least amount of fence because you want to keep your costs low. Things to do:

1. Draw on graph paper 4 different pen shapes that enclose 144 square yards.

2. Figure the fence (perimeter) needed to enclose 4 different pasture shapes that enclose 144 square yards. Show how you figured the perimeter.

Perimeter 1:

Perimeter 2:

Perimeter 3:

Perimeter 4:

3. If the fence costs 8 dollars per yard, what is the cost of fence for each of the 4 shapes you drew?

4. What is the best shape to use for the pasture? Explain why!
Appendix J  Problem Solving Group Form on Lesson 80, Problem 1

1. Understand the Problem.
   a. Can I picture or visualize the problem? Show what you see with a picture or model. Yes
      
      \[
      \text{[Diagram showing 6 quarts]} \\
      \]
   b. What background knowledge do I have about this problem?
      
      I know liquid measure.
   c. What new words or terms do I need to know to solve the problem? None
   
   c. Have I ever solved a similar problem? Yes
   
   e. Restate the problem in my own words. The family had 9 quarts of milk and they drank two quarts. How much was left?
      
      [Blank lines for restatement]

2. Plan the Problem
   a. What should you do first? Is there a simpler problem I have to solve first?
      
      Yes, you can make two gallons into 8 quarts and then you subtract two quarts
b. What operations should you use?

Subtraction

3. Follow your plan and check your steps. Write your problem here and work it out. Show checking of your solution.

\[
\begin{align*}
2 \text{ gal} & = 8 \text{ quarts} \\
- 2 \text{ quarts} & \\
\hline
6 \text{ quarts} & \\
+ 2 & \\
\hline
8 & = 2 \text{ gal}
\end{align*}
\]

4. Reflect about your problem solution.

a. Is my answer reasonable?

Yes

b. Can I check my answer to see if my computation is correct?

Yes

c. Is there another or different way to solve this problem?

No
Appendix K Progressing Student’s Work on Problem Solving
Story problems for student interviews Progressing, Proficient and Advanced.

I would like you to pick two of these problems to work on, saying aloud what ever it is you are thinking as you work through the problems. I especially want to hear you talk about how you decide what to do to solve the problem. I would also like to know why you picked the two problems you picked.

1. Albert baked 5 dozen cookies and gave away 7/12 of them. Then how many cookies were left?

2. What is the quotient when the decimal number ten and six tenths is divided by four hundredths?

3. Robert packed boxes that were 1 foot long, 1 foot wide, and 1 foot high into a larger box that was 5 feet long, 4 feet wide, and 3 feet high.
   a. How many boxes could be packed on the bottom layer of the larger box?
   b. Altogether, how many small boxes could be packed in the larger box?

4. The cost to place a telephone call to Tokyo was $1.50 for the first minute plus $1.00 for each additional minute. What was the cost of a 5-minute phone call?

5. Bianca poured four cups of milk from a full half-gallon container. Then how many cups of milk were left in the container?
Story problems for student interviews Progressing,
Proficient and Advanced.

I would like you to pick two of these problems to work on,
saying aloud what ever it is you are thinking as you work
through the problems. I especially want to hear you talk
about how you decide what to do to solve the problem. I
would also like to know why you picked the two problems
you picked. They were the ones I think I do now.

1. Albert baked 5 dozen cookies and gave away 7/12 of
them. Then how many cookies were left?

2. What is the quotient when the decimal number ten and six
tenths is divided by four hundredths?

3. Robert packed boxes that were 1 foot long, 1 foot wide,
and 1 foot high into a larger box that was 5 feet long, 4
feet wide, and 3 feet high.
   a. How many boxes could be packed on the bottom
      layer of the larger box?
   b. Altogether, how many small boxes could be packed
      in the larger box?

4. The cost to place a telephone call to Tokyo was $1.50 for
the first minute plus $1.00 for each additional minute.
What was the cost of a 5-minute phone call?

5. Bianca poured four cups of milk from a full half-gallon
container. Then how many cups of milk were left in the
container?
Appendix L Work on Structured Form

1. Understand the Problem.
   a. Can I picture or visualize the problem? Show what you see with a picture or model.
   - Someone baked 12 cookies and gave 7 away. How many cookies were left?
   - Yes.
   b. What background knowledge do I have about this problem?
   - I know what a dozen is.
   c. What new words or terms do I need to know to solve the problem?
   - Dozen
   d. Have I ever solved a similar problem?
   - Yes.
   e. Restate the problem in my own words.
   - Yes.

2. Plan the Problem
   a. What should you do first? Is there a simpler problem I have to solve first?
   - Find how many dozen is.
   - Yes.
b. What operations should you use?
   multiply, draw a chart

3. Follow your plan and check your steps. Write your problem here and work it out. Show checking of your solution.

   \[
   \begin{array}{c}
   12 \\
   \times \frac{5}{60} \\
   \hline
   60 \\
   \end{array}
   \]

   \[
   \begin{array}{c}
   10 \quad 12
   \hline
   7 \text{ given away}
   \end{array}
   \]

   \[
   \begin{array}{c}
   5 \text{ left, 16 cookies}
   \hline
   \end{array}
   \]

4. Reflect about your problem solution.

   a. Is my answer reasonable?
      Yes

   b. Can I check my answer to see if my computation is correct?
      Yes

   c. Is there another or different way to solve this problem?
      Yes
Appendix M

Area and Side Length Problem From Algebra ½ Passports

Please work this problem carefully. Remember to write the steps below telling me what you did first and why you did it. Explain what you know about area.

Use the figure below to help you figure the length of side X.

The shaded region has an area of 36 square units. The white region has an area of 24 square units. How long is side X?
Appendix N Group Work

The work appears on the next page. Here is typed transcription of what was written on the problem page.

First explanation:

Area (a) is the length X width
Next you find the area of the whole box by adding
Divide the area by one side
You come up with 10

Second explanation:

Area is the length time(s) the width
Next you have to find the area (a) of the whole box by adding
Divide the area by one side
You come up with 10
Story Problem Reading and Solving Form by Geri Steinbrink

Names: ____________________________________________________________

1. Understand the Problem.
   a. Can I picture or visualize the problem? Show what you see with a picture or model.

   ![Picture](image)

   b. What background knowledge do I have about this problem?

   I know how to find area.

   c. What new words or terms do I need to know to solve the problem?

   region

   c. Have I ever solved a similar problem?

   Yes

   e. Restate the problem in my own words. Find the length of x

   _______________________________________________________________
   _______________________________________________________________
   _______________________________________________________________
   _______________________________________________________________

2. Plan the Problem

   a. What should you do first? Is there a simpler problem I have to solve first?

   Add 3 \( \text{by} \text{to} \text{and} 2 \text{by} \text{to} \text{first} \).
b. What operations should you use?
   - Adding
   - Dividing

3. Follow your plan and check your steps. Write your problem here and work it out. Show checking of your solution.

\[
\begin{align*}
36 \\
+ 24 \\
\hline
60 \\
\div 60 = 10
\end{align*}
\]

4. Reflect about your problem solution.
   a. Is my answer reasonable?
      
      \( \text{Yes} \)
   
   b. Can I check my answer to see if my computation is correct?
      
      \( \text{Yes} \)
   
   c. Is there another or different way to solve this problem?
      
      \( \text{No} \)
Please work this problem carefully. Remember to write the steps below, telling me what you did first and why you did it. Explain what you know about area.

Use the figure below to help you figure the length of side x.

The shaded region has an area of 36 square units. 
The white region has an area of 24 square units. 
How long is side x?

- Area is the length x width
- Next you find the area of the whole box by adding
- Divide the area by one side
- You come up with 10
Please work this problem carefully. Remember to write the steps below telling me what you did first and why you did it. Explain what you know about area.

Use the figure below to help you figure the length of side $x$.

![Diagram of a rectangle with shaded and white regions.]

The shaded region has an area of 36 square units. The white region has an area of 24 square units. How long is side $x$?

- Area is the length times the width.
- You have to find the area of the whole box by adding.
- Do the numbers by one side.
- You came up with 10.
Appendix O Journal Entries about Relationship between Vertices, Faces, and Edges

These are transcriptions of the journals of three students.

Student 1

Sir Cumferance(sic) had to find different solids like us by folding paper. If you add together the faces and vertices and subtract the number of edges you always get 2, except for a cone and a cylinder(sic). The sward(sic) was in a cone.

If you add the faces and vertices and subtract 2 you get the edges. Platonic solds have and are 3-D shapes.

Student 2

You have 6 faces, 8 vertices, and 12 edges of a cube. To get the edges you have to add 6 + 8 = 14 then subtract 2 & the answere(sic) will be 12.

Cube Faces (6) + Vertices (8) – 2 = Edges (12)

Student 3

They are the same because we had to put both of them together, and they are both geometric solids. I learned that all the edges, vertices, and faces are similar. Plantonic(sic) solids are not flat they are 3D.

If you go in order, Faces + Vertices = Edges, you plus the faces & vertices. Then you subtract 2 from that answer, and you have your number of edges.
Week 5: What is the relationship between our Investigation of Platonic Solids and Lesson 90 in our math book to the book Sir Cumference and the Sword in the Cone? What did you learn about edges, vertices, and faces? Please tell me in your own words what you learned about platonic solids.

Sir Cumference had to find different solids like us by folding paper. If you add together the faces and vertices and subtract that from the number of edges you always get 2, except for a cone and a cylinder. The sword was in a cone.

If you add the faces and vertices and subtract 2 you get the edges. Platonic solids move and are 3-D shapes.
Week 5: What is the relationship between our Investigation of Platonic Solids and Lesson 90 in our math book to the book Sir Cumference and the Sword in the Cone? What did you learn about edges, vertices, and faces? Please tell me in your own words what you learned about platonic solids.

You have 6 faces, 8 vertices, and 12 edges. To find the edges, you have to add 6 + 8 = 14, then subtract 2 and the answer will be 12.
Week 5: What is the relationship between our Investigation of Platonic Solids and Lesson 90 in our math book to the book Sir Cumference and the Sword in the Cone? What did you learn about edges, vertices, and faces? Please tell me in your own words what you learned about platonic solids.

They are the sides, only

and then a little off
to the right, and then
it was a question mark,
and then there were
been, or was there a set for there and 3D.

If you go to the right, the right stage,
you get it for yourself. That is
something that you can have or
\[ 3 \times 3 \]
Appendix Q  Math Olympiad Problem

On the next pages you will see the Math Olympiad Test and the answers that the students got right. Then you will see the structured problem solving form that the two students filled out for a problem on which they used the form.

Transcription from the last page which does not show up well.

c. Is there another or different way to solve this problem?

Maybe, but I don’t think so. It be pretty hard to do it another way.
5A Time: 4 minutes
Sara said, "If you divide my age by 3 and then add 8 years, the result is my age." How old is Sara, in years?

5B Time: 5 minutes
In the list of numbers 5, 8, 11, 14, ..., each number is 3 more than the number before it. What is the first number in the list that is greater than 100?

5C Time: 7 minutes
In the following, different letters represent different digits. What digit does the letter O represent?

\[
\begin{array}{c}
\text{O N E} \\
+ \text{FOUR} \\
\hline
\text{F I V E}
\end{array}
\times 4
\text{FOUR}
\]

5D Time: 7 minutes
Each of 10 tiles has one of the numbers \{1,2,3,4,5\} written on its front and a different one of these numbers on its back. No two tiles have the same pair of numbers. The fronts of the tiles are shown. What is the fewest number of tiles you can point to and be sure that (at least) one of them has a 5 on its back?

5E Time: 5 minutes
Suppose symbol # means that
\[
A \# B = (A \times A) - (B \times B)
\]
and that A and B represent any two numbers.
What is the sum of \((8 \# 7)\) and \((7 \# 1)\)?
<table>
<thead>
<tr>
<th>Student Name and Answer</th>
<th>5A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+1</td>
</tr>
<tr>
<td>12 years</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student Name and Answer</th>
<th>5B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student Name and Answer</th>
<th>5C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student Name and Answer</th>
<th>5D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student Name and Answer</th>
<th>5E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+1</td>
</tr>
</tbody>
</table>
Story Problem Reading and Solving Form by Geri Steinbrink

Names: ______________________________________

1. Understand the Problem.
   a. Can I picture or visualize the problem? Show what you see with a picture or model.

b. What background knowledge do I have about this problem?
   - means you the first and second number by itself and subtract the product

c. What new words or terms do I need to know to solve the problem? find

   c. Have I ever solved a similar problem?

   Yes

   e. Restate the problem in my own words.

2. Plan the Problem

   a. What should you do first? Is there a simpler problem I have to solve first?
b. What operations should you use?

\[ \frac{8}{64} \times \frac{7}{49} \]

and

\[ \frac{15}{63} \]

3. Follow your plan and check your steps. Write your problem here and work it out. Show checking of your solution.

\[ \frac{8}{64} \times \frac{7}{49} = \frac{56}{3136} \]

4. Reflect about your problem solution.

a. Is my answer reasonable?

\[ \text{YES} \]

b. Can I check my answer to see if my computation is correct?

\[ \text{YES} \]

c. Is there another or different way to solve this problem?

\[ \text{most likely} \]
\[ \begin{align*}
\text{t} &= 5 \\
F &= \\
V &= 124 \\
N &= 3 \\
A &= 4 \\
I &= \\
\theta &=
\end{align*} \]

\[ \begin{align*}
17, 20, 23, 26, 29, 35, 41, 47, 50, 53, 56, \\
59, 62, 65, 74, 77, 80, 83, 86
\end{align*} \]

\[ \frac{4}{112} = \frac{\theta}{12} \]

\[ \begin{array}{c|c|c|c|c}
\text{t} & \text{a} & \text{b} & \text{c} & \text{d} \\
\hline
4 & 4 & 4 & 4 & 4 \\
\hline
4 & 8 & 12 & 16 & 20 \\
\end{array} \]

\[ \begin{align*}
\frac{335 + 335}{1340} &= \\
\frac{670}{1340} &= \frac{335}{670} \\
\end{align*} \]
5A  Student Name and Answer

12 + 1

years

5B  Student Name and Answer

101 + 1

5C  Student Name and Answer

\[ \text{4} \]

5D  Student Name and Answer

1

5E  Student Name and Answer

\[ \text{6} + 1 \]
b. What operations should you use?

I used division and addition.

3. Follow your plan and check your steps. Write your problem here and work it out. Show checking of your solution.

\[
\begin{align*}
  9, 6, \ 7, 12 \rightarrow 2, 2, 7, 12, 20 \quad \text{Checking} \\
  12 \div 3 = 4 \\
  4 + 8 = 12 \quad \text{Answer}
\end{align*}
\]

4. Reflect about your problem solution.

a. Is my answer reasonable? \( \checkmark \)

b. Can I check my answer to see if my computation is correct? \( \checkmark \)

c. Is there another or different way to solve this problem?

I'm not sure if I did think about it being pretty hard to do it another way.
Appendix R Problem Solving Sheet for Circumference

Recording Sheet for Circumference       Names______________________________

Cut a length of string the same measure as the diameter, and then you will begin wrapping the string around the object. Mark the object at the end of the string; then move the string and wrap the object again. You will estimate the number of diameters needed to reach around each object.

The Number of Diameters in a Circumference

Part 1: Estimates (using string)

<table>
<thead>
<tr>
<th>Object</th>
<th>Approximate Number of Diameters in Circumference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
</tr>
</tbody>
</table>

What did you discover about the number of diameters it took to go around the circumference of the circular object you found?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
Part 2: Measures (using tape measures)

In the second part of the activity, you will use a tape measure to measure the circumference and the diameter of the same objects. Record the measure of the circumference and diameter to the nearest tenth of a centimeter. Then divide the circumference using the calculator.

<table>
<thead>
<tr>
<th>Object</th>
<th>Circumference</th>
<th>Diameter</th>
<th>Circumference divided by Diameter = Quotient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

1. Now find the average of all the quotients in the last column. What did you discover? Is the average similar to anything you have seen before?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. What is the relationship between the circumference and diameter of the circle?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Appendix S Journal about Reading Strategies

Transcriptions of Journal entries that do not show up well.

Journal Week 6: Bill

How are the reading strategies helping you? Who do you feel when I ask you to do a story problem independently? How do you feel when I ask you to do a story problem with a group? Have you noticed any improvement in your problem solving ability since we have used the structured problem-solving form?

The reading strategies make a big difference (sic). When you ask a story problem I can usually get it. When I have a group I feel a lot better. My ability has gotten better.

Journal Week 4: Carmen

Next week we will be taking the ITBS math problem solving test. What could help you do well as you read the problems? What reading strategies do you plan on using as you do the problem solving and concept parts?

- Read
- Write
- Act out
- Find with multiply, add, subtract, and divide
- Re – Read
- Answer
Week 6: How are the reading strategies helping you? How do you feel when I ask you to do a story problem independently? How do you feel when I ask you to do a story problem with a group? Have you noticed any improvement in your problem solving ability since we have used the structured problem-solving form?

Next week we will be taking the ITBS math problem solving test. What could help you do well as you read the problems? What reading strategies do you plan on using as you do the problem solving and concept parts?

- Read
- Write
- Act out
- Solve with multiply, add, subtract, and divide
- Re-read
- Answer