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Enhancing Thinking Skills: Will Daily Problem Solving Activities Help?

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ABSTRACT

In this action research study of my classroom of eighth grade general mathematics students, I investigated how addressing problem solving activities each day would affect the thinking and reasoning skills of the students. I discovered that the students became more adept at problem solving as they practiced various strategies. As students justified their answers, both orally and in written form, their understanding of mathematics and its applications to the real world improved. I discovered that students worked more diligently on problems of interest to them. Also, some problems are better solved individually, and some are more geared as a group activity. As a result of this research, I plan on allotting time for problem solving in all of my math classes next year. I will give students the opportunity to work in groups, but they will also be required to complete some problems individually

Introduction

Will teaching problem solving strategies and activities daily improve the students' problem solving capabilities? I chose problem solving as the topic of my research because I was frustrated with the problem solving skills exhibited in my eighth grade general mathematics class. Some students just seemed to guess when they encountered any type of word problem. I want students to be able to read the problem, decide what is being asked and find a reasonable solution. The textbook I use has some word problems in it, but I would not necessarily consider solving them problem solving. However, these word problems provided a starting point for my research. Students were very dependent upon me for guidance when a word problem was encountered. It was easier for my students to ask me for help than to try to figure out how to solve the problem. Students need to become independent problem solvers. Being able to read a problem and decipher the vocabulary is a life skill every student needs. This can assist the students in deciding which strategy to use to solve the problem. Students need the tools to problem solve, which is why I chose problem solving as the topic for my action research.

As students are given a variety of problem solving activities, will their understanding of math and how it relates to many different situations in the real world change? The students think that mathematics is a subject which stands on its own and does not relate to the real world. My goal is to help students understand that mathematics is useful in many different situations in the real world. However, the real-world examples require the students to understand that each situation has its uniqueness and requires the students to figure out which mathematics will be useful to solve each situation. I want to research how student communication of their solutions

orally and in written form will affect the understanding of how mathematics relates to a variety of situations.

If students are interested in the topic of the problem solving activities, will it affect the time and effort the student is willing to extend to solve the problem? Do the students work harder on problems that are of interest to them? Topics will vary with the problems presented to the students daily. Some of the problems will be of more interest to the students. However, what is of interest to one student could be of little interest to another. Some problems may be of little interest to any of the students, and some problems may be of interest to most of the students. Most teenagers like sports, shopping, friends, phones, computers, etc. The problems that address these topics will be of more interest to the majority of the students. Some of these problems will be solved using similar strategies. My goal is that the students will be able to solve many types of problems.

Problem Statement

Why is it important to become a good problem solver? Problem solving is useful in everyday life. Everyone needs to know how to analyze a situation and decide how to solve the problem related to the situation. Students are confronted with many types of problems which need to be analyzed and for which they need to decide which strategy would work best to solve the problem. Problems do not occur just in the classroom, but in athletics, music, the work force, and at home. Students need to become better problem solvers.

The same is true for people in all facets of life. No matter what type of work one is doing, problems arise daily. Every person needs to be able to analyze the situation and decide how to solve the problem. When one becomes a homeowner and has family responsibilities, many problems arise. Problems may not all involve mathematics, but analyzing the problem is

still essential. Other teachers may be interested in the topic of problem solving. Students are confronted with problems in every class. The problems may differ in type and topic, but they are problems just the same. As students improve in their analysis skills, they should improve in their performance in all areas of their life. As students graduate and move on to college or the work force, improved problem solving skills will always serve them well.

Literature Review

My problem of practice is to investigate whether spending at least 15 minutes a day on problem solving activities improves the understanding of mathematics in my mathematics classroom. I am frustrated with the lack of problem solving skills in my eighth grade math students and would like to help them acquire better reasoning skills. I want to know if spending time on problem-solving activities daily will encourage students to become more willing to spend the time to solve problems. I am also curious to know if tailoring problems to student interests will increase the perseverance of the students. I would like each student in my room to become an active participant when working in a group as well as a capable problem-solver as an individual. As I read articles on problem solving in different settings, the themes of changes in curricula, group work, student understanding and communication of mathematics, and problem-solving of real life problems that were of interest to the students emerged repeatedly.

Since I am researching problem-solving, the first place I went was to the National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School Mathematics*, 2000. The Problem Solving Standard states:

> Instructional programs from pre-kindergarten through grade twelve should enable all students to:
>
> > Build new mathematical knowledge through problem solving.

Solve problems that arise in mathematics and in other contexts.

Apply and adapt a variety of appropriate strategies to solve problems.

Monitor and reflect on the process of mathematical problem solving. (p. 256)

These statements give all mathematics instructors in the United States goals for which to strive. These statements give me, as a math teacher, guidelines as to what my classroom should look like. As I completed research of problem solving, I noticed repeated themes of change of curricula, group work, student understanding and communication of mathematics and choosing problem solving activities that were of interest to the students were addressed often. Problem solving should be used to help students learn mathematics and understand how math can be used in many areas of life.

Changes in Curricula

With the publishing of the mathematics standards by the NCTM in 1989, came many changes in mathematics curricula. Many textbook publishers began striving to publish textbooks that would meet the standards. Concerns with students' abilities to solve problems, not just perform basic computation led to many changes in curricula. The change in curricula is apparent in many research articles. Some of the articles discuss problem-solving based curricula which stand alone. One of the new curricula is *The Middle-School Mathematics through Applications Project Group* (Greeno, 1997). Greeno has published many articles including *The Handbook of Educational Psychology*, and *The American Psychologist*. This project was sponsored through the Institute for Research on Learning and Stanford University. The project's main goal was to design resources that would help all students learn mathematics. The three perspectives were learning to think and acquire higher-order skills, learning to think and understand strategies for reasoning and learning to think and making sense of the relations of mathematics and society.

Greeno and the other participants of the project accomplished this by developing computer programs. The computer programs were designed to help middle school students learn mathematics as a resource for understanding how mathematics fits into real life. This project explains learning as, "students become effective participants in practices of mathematical thinking and acting that include communicating, inquiry, reasoning and understanding" (Greeno, 1997, p. 100). These computer design systems were examples of stand alone curriculum. They are designed to require an extended period of time to complete. Students may spend weeks working on one project. The students are required to understand the material and the mathematics involved in each project.

Campbell, Kemp and Zia (2006) developed another problem based curriculum at Phillips Exeter Academy in Exeter, New Hampshire. This curriculum was designed to meet the NCTM (2000) standards. The problem sets are topic-based with no chapters and no answers in the back of the book. Mathematical concepts are developed completely in the problem sets. There are many threads on one page and the students are encouraged to find the connections between these threads. Campbell and Kemp are colleagues at Phillips Exeter Academy. Zia is interested in technology and has presented workshops on blending it with other curricula. This curriculum was developed for secondary students, requiring the students to investigate problems, make conjectures, and test the conjecture. The students then presented their findings to the class. Students were assigned seven or eight problems each night.

Comparing these two curricula, they have the same goal of teaching students to become better problem solvers. However, the curricula differ in the way they are presented to the students. In Greeno's project (1997), the students worked on one problem for an extended length

of time. In Campbell, Kemp, and Zia's (2006) curriculum, the students were given a different assignment each night. Connections to the real world and other concepts of mathematics. Sometimes, instead of purchasing a new curriculum, one has to implement problem-solving into the curriculum already available

As I planned my research, my intent was to spend about 15 minutes daily on problem solving. I tried to find problem solving activities that are of interest to the student and that address the mathematical concepts in the state and national standards and in the current curriculum. My research involved a variety of problem solving activities that varied daily. Students were asked to present their solutions both orally and in written form. I hoped students' understanding of mathematics and confidence as a problem solver would improve.

Group Work

NCTM would like teachers to implement more group work in their classrooms. However, the movement toward group work is sometimes slow. Albert (2000) performed a fourteen week study of thought processes of seventh graders. Albert's research reports on a study of seven middle grade students. These seven students were representative of a larger group. The intent of this study was to research activities where students worked in groups and eventually turned the "group talk" into "self talk" where they were able to solve problems individually. As students worked in groups, they solved problems, but later they each individually were wrote a solution, which included strategies and procedures they used to solve the problem. The research showed significant improvement in students in the experimental group over students in a regular mathematics classroom. The curriculum developed by *The Middle School Mathematics through Applications Project* (Greeno, 1997) was designed to be used by groups. Working in groups can give each student a chance to succeed. *Bugs, Planes, and Ferris Wheels* (Campbell, Kemp & Zia,

2006) is also a curriculum designed for group work. Many strands and threads are addressed in each lesson. By having students work in groups, one student may discover a strand that others don't. Students come to class with varying levels of mathematical competence but each can still be a contributing group member.

The role of the teacher changes when students are engaged in group activities. Many times the teacher becomes the gatherer of necessary materials. Other times the teacher has the role of mediator. Instead of being a dispenser of knowledge, the teacher steps back and watches the students work and becomes a co-participant in the learning process. Choosing appropriate problems is the primary concern of the teacher (Albert, 2000; Cobb, 2001; Greeno, 1997; Stillman & Galbraith,1998).

The research addressing group work had many similarities and a few differences. Age of the students was one of the differences. Albert (2000) and Greeno (1997) performed research on seventh graders, while Stillman and Galbraith (1998) and Campbell, Kemp and Zia (2006) worked with secondary school students. Even though the age of the students differed, the types of projects were similar. The students worked in groups and shared their solutions with the whole class in many instances. In some of the studies, students shared their solutions orally, but in Albert's research, there was an emphasis on the written solution.

The research I planned more closely resembled the research of Campbell, Kemp and Zia. I found problem solving activities that are related to the topics I was teaching each week. I assigned students to a group each week. Some days they are actually involved in working as a group, and some days they are just sitting in close proximity. I planned to have students work in groups some days and individually other days. I believe it is important for students to be able to communicate their thought processes and solutions. Because of this, I had the students share their

solutions, which included why they chose a certain strategy, their thought processes and the solution to the problem. I, like Albert (2000), want to have the students write their solutions. I believe that writing the solutions in paragraph form helps the students to better understand the mathematical processes.

Student Understanding and Communication of Mathematics

The goal of improving problem-solving abilities is that students will better understand mathematics and be able to communicate that understanding to other students and to the instructor. Many authors speak of the advantages of teaching mathematics through a problem-solving approach. An example of this is Trafton and Midgett (2001). Trafton teaches at the University of Northern Iowa, Cedar Falls, IA. Midgett is a teacher-in-residence at the University of North Carolina at Wilmington, Wilmington, NC. They discuss a fourth grade classroom where students are given the problem of two pieces of gum to divide among three people. How much gum does each person get? This problem may be approached in many different ways. Students were given time to solve the problem, then asked to share their answers with the class.

Problem-centered activities contribute to student learning in several ways. These include being able to make connections between their out-of-school experiences and school mathematics, and being able to communicate their thought processes by working in small groups or as a whole class. Students learn to choose strategies because they make sense, not just by memorizing what to do in a certain situation. Students will learn from the many real-life projects, and will develop more confidence as problem solvers and become mathematical risk-takers. “In classrooms that stress sense-making and communication, children learn to listen to one another, respect the thinking of others and become confident in their capabilities as mathematics students” (Trafton & Midgett, 2001, p. 535). Albert (2000) stated that students in the problem solving group

showed significant improvement in their understanding of problems and in their use of problem-solving strategies. In this study, students were expected to write solutions and it was found that writing improved the students' understanding of problems. This was thought to be because writing is slower than verbally expressing an answer. This forces students to repeat the processes they went through and revisit each stage of solving the problem.

Lampert (2004), a pioneer of mathematics teaching and learning, reinforces the idea that the students will learn more by problem-solving in the classroom. In her article, Lampert mentioned Polya, the father of problem solving. Polya stated that students need intellectual courage, intellectual honesty and wise restraint when problem solving. Students can develop these traits by being exposed to problem-solving activities. There seems to be a consensus that problem-solving activities help students develop a better understanding of mathematics. Having students write solutions helps develop understanding and a mathematical vocabulary (Albert, 2000; Cobb, 2001; Greeno, 1997; Stillman & Galbraith, 1998). Teaching mathematics through a problem centered approach helps students to develop reasoning skills. It gives students more freedom to approach a problem in different ways and to try to understand what makes sense. It is best said in the following quotation, "Instruction ought to allow students to wonder why things are, to inquire, to search for solutions and to resolve incongruities. It means that both curriculum and instruction should begin with problems, dilemmas, and questions for students" (Erickson, 1999, p. 516). Erickson teaches at Oregon State University and is interested in mathematics teaching strategies, equity issues and technology.

The role of the teacher changes with a problem centered approach. The teacher presents a problem, becomes an observer, encourager, and mediator. The teacher is no longer the person that tries to rescue the struggling student. The teacher now lets the student struggle, not feeling

guilty about it. That statement gives me a challenge as to what my teaching should do to and for the students each day. Instead of giving students information, I should give them problems which they have to solve.

The research concerning student learning and problem centered instruction is abundant. There seems to be a consensus among researchers that students learn more with a problem centered approach than in a traditional mathematics classroom. Students have more freedom deciding how to solve problems. Using a problem centered approach is suitable for many different ages of students. No matter the age of the student, a problem centered approach seemed to be beneficial. The problem needs to be age appropriate, but all ages of students benefit from problem centered instruction.

Using a problem centered approach of instruction is a goal of my research. I presented a problem to the students at the beginning of each class period. The students then were given time to solve the problem. Like Albert (2000), I am concerned with having the students submit written solutions to the problem, since writing solutions help student communication of mathematical vocabulary and mathematical reasoning. Students need to be able to choose an appropriate strategy and be able to tell the other students why they chose the strategy as well as describe their thought process and solution.

Problem-solving Aimed at Specific Student Interest

Erickson (1999) states that teachers must use their knowledge of mathematics and of their students to choose appropriate problems. This knowledge should ensure that students see the relevance in the skills it takes to solve the problems. This is a challenge, especially since the experiences of students vary widely. Students many times do not see any relevance or connection to the real world in the mathematics they are learning. Trafton and Midgett (2001) speak of an

elementary classroom in which students like to solve division problems involving how many cookies each student will get from a box of a given number of cookies. The students can see the connection of division to the real world. Connections are harder to find for students as the mathematics they are working with becomes more difficult and advanced. Many students never see the relevance of fractions, area, algebra and the like. Greeno (1997) and Campbell (2006) had similar concerns when they started developing their respective programs. Even if every problem is not of direct interest to the student, I believe the students will better understand the concepts if they see relevance to the real world. Trafton (2001) also used a problem of interest to the students when they were asked how to divide two pieces of gum among three people. It is the role of the teacher to develop problems that will interest the students and will require mathematical skills to solve.

> Problem solving is natural to young children because the world is new to them and they exhibit curiosity, intelligence, and flexibility as they face new situations. The challenge at this level is to build on children's innate problem-solving inclinations and to preserve and encourage a disposition that values problem solving. (NCTM, 2000, p. 116)

This statement was found in the Pre-K-2 section, but is a true statement at any stage of a student's life. Erickson (1999) also states that problem solving activities may have many roles in the classroom. These activities can be used to introduce a new topic or concept, to develop understanding of a concept, or to apply a concept.

Research involving real life applications of mathematics problems varies greatly. Some are stand alone curricula such as Greeno's (1997) project and Campbell's (2006) curriculum. However there are other problems that can be used as supplements to current curricula. As an educator, it is my responsibility to find problems that will interest and challenge my students.

The NCTM is one resource that is very helpful when searching for problems. In addition to the NCTM, there are many books and websites that include problem solving activities.

My role as a teacher is changing with more emphasis placed on a problem centered approach. This means that I must find resources that have problems and must choose appropriate problems for each situation. By finding problems that are of interest to the students, student interest and understanding of mathematics should improve. After the students work problems and see the relevance, connections to other areas should become apparent.

Conclusion

As I completed reading research articles, I realize that I have many places to go for help with my action research. I now realize I need to teach using a problem-solving approach, and not teach problem solving as a separate entity. This is very challenging for me. One article I read was a hypothetical dialogue of three teachers, Cara, Anne and Ben, discussing a problem solving seminar they had attended. Lubienski (1999) pointed out the differences of teachers and their opinion of what is meant by teaching problem-solving. Lubienski at the time this article was published taught at Buffalo State College in Buffalo, NY. She was involved with the Education Policy and Practice Study housed at Michigan State University. The three teachers in this article, had very different ideas about the teaching of problem solving. Anne looked at problem solving as teaching the strategies, then having the students complete the word problems at the end of each chapter. In addition Anne had begun collecting puzzles, games and other problem-solving activities. She also believed in order to teach more problem solving she would have to eliminate something from her current curriculum. Cara, the second teacher, wondered how she could be sure if the students learned the math they needed if she used problem-centered activities. However, she did tend to let her students struggle with how to find the answer. She planned

ahead for which questions she wanted to ask to insure the students were learning the material. She admitted to the others that she had seen problem solving used as a powerful way to introduce new material. In addition, Cara knew that students learned best when they could make sense of the mathematics. Ben let the students explore and solve the problems, then discussed how the students solved the problem.

As I read this article, I feel as if I am like Anne, and know I need to be more like the other two. I teach about problem solving many times, but do not teach using a problem solving approach. As I planned my action research, I wanted to find problems that would enhance my current curricula and be of interest to the students. My intent was to spend at least fifteen minutes each day on solving a problem solving activity. Students would present their solution either orally or in written form to the class. The main goal was that student learning and understanding of mathematics improve. With this understanding, I hoped students would see connections and be able to solve a variety of problem-solving activities.

Purpose Statement

I am interested in helping students become more self-sufficient. Because of this, I chose to research how to help them become better problem solvers. The purpose of my research study is to observe the affect of addressing problem solving daily in my eighth grade mathematics class. I am curious to see if the students will become better problem solvers with practice. Will the students' confidence in their mathematical ability increase with practice in problem solving? Also, I want to see if the students will improve in their mathematical communication with practice on problem solving. The following are my research questions:

1. What will happen to the quality of student written communication and reasoning to solve problems after I spend time regularly teaching problem solving?

2. What will happen to the student willingness to attempt word problems if the word problems are about topics of interest to them?

3. What will happen to the quality of mathematical communication between students and student-to-teacher once students practice problem solving daily?

4. How will my teaching look when I spend more time teaching problem solving?

Method

I started this action research project the first part of February, 2008. My research project took place in my eighth grade mathematics class of seven students. The students had average to below average success in previous mathematics classes. I began this project by having the students fill out a survey (see Appendix A). The survey included questions about their feelings about mathematics, their feelings about presenting solutions to the class, the importance of math and group work. The students were also questioned pertaining to writing solutions and problem solving.

In addition to the survey, I conducted interviews with all seven students (see Appendix B for interview questions). The interview included questions referring to the students' feelings when solving word problems, when working in groups, and their work effort when the problems were about a topic of interest to them. Questions pertaining to student confidence in mathematics in general and in problem solving were also asked. The interview also included solving two problems and explaining their work. The solution to one problem was explained orally and the other in written form. These interviews occurred the third week of February. The students were interviewed a second time the first week of May. The second interview included two additional questions. The students were asked their feelings about writing solutions in paragraph form and

if they had any advice for me pertaining to next year. The student responses were compared on pre and post interviews.

The first week of February, I began spending time daily on problem solving. A problem was presented to the class and they would work on it. Problems varied in difficulty and time required to solve them. Some of the problems only required fifteen or twenty minutes to solve, but others required the entire 55 minute class period. A few of the problems even required additional time the next day. As the students worked, I circulated and observed. I recorded observations in my journal. Each of the students had a three ring binder in which they kept their problem solving activities. These binders helped with organization and analysis of the data. By keeping all of one student's work in a binder, I was able to see the progress of written work and explanations. I varied the topics covered by the problems so I could see if the students worked harder on the problems of interest to them. Since we have a four day school week, it was sometimes difficult to do a problem solving activity each day. When one factors in interruptions such as achievement tests, athletics, snow days, and field trips, the number of instructional days occasionally decreased to two. Collection of data became increasingly difficult during those weeks.

Every two or three weeks, students picked their favorite problem to write out a solution for and explained why it was their favorite problem. When I began my research project, I planned to do this weekly. Lack of instructional days also caused difficulty in this aspect of the project. These written descriptions were scored with a rubric (see Appendix C) and were kept in their three ring binders.

Test scores and daily work were also important sources of data. Scores were kept in my grade book. Since both daily work and tests include word problems, I was interested to see if the

students would improve in these areas. I recorded observations while students were working on tests and daily work in my teacher journal.

Findings

Teaching in my eighth grade classroom changed drastically during my action research project. Prior to the beginning of my action research project I addressed problem solving sporadically. If time allowed, I would present the students with a problem solving activity. Each class period is 55 minutes long. The class period would be spent going over the assignment the students had completed in class or the night before, presenting new material and the students working on an assignment that covered the new material. Usually, going over the assignment from the day before took about fifteen minutes. This involved reading the answers to the students and addressing any questions they may have. The students then turned their papers in for grading. The next fifteen minutes were used for me to present the new material. This usually involved discussing the new vocabulary and me doing examples on the board. The students were observers and not actively involved. The students worked on the assignment for the remaining part of the class period. The assignment was usually 25 to 30 problems.

My action research began the first week of February, 2008. With this came many changes in my classroom. The main change was that problem solving was addressed first and the remaining time was spent on explanation of new material and the students working on a daily assignment. With the beginning of my action research, I changed the focus of learning in my classroom to problem solving. During my action research, each class period began with the students being presented a problem solving activity. They were given time to work on the problem. The time varied from fifteen minutes to the entire 55 minute class period. The students sometimes worked problems as a group, and other times worked individually. After the students

had sufficient time to solve the problem, the solutions were presented to the class. Some of these presentations were given in groups of two or three and others individually. The presentations included writing their work on the board and explaining their work and thought process to the class. Two or three students usually presented their solutions. However, for some problems, every student presented their solution. By having solutions presented, students were able to see that many problems could be solved using different strategies. After the solutions had been presented, the students turned their problems in to me so I could keep a collection of their work.

Basic skills and concepts were practiced for the remainder of the class period. These basic skills and concepts included integers, fractions, percents, decimals, area, perimeter and volume. Sometimes this practice was completed with students working at the board, and other times the students completed the problems with paper and pencil. After a review of the concept of the day, the students usually had ten or fifteen minutes to work on the assignment. These assignments were usually only ten or fifteen problems.

Focusing on problem solving caused the students to become much more active participants in class. Each student was responsible for working on the problem of the day. If students were working in groups, each person actively participated in the group. Class participation became much more representative of the class as a whole. The number of students who were sitting passively decreased. Students volunteered to present solutions and became better at explaining their reasoning to each other and to me.

My teacher role changed during my action research. Prior to my action research, I stood at the front of the class and dispensed knowledge. I gave the students the information they needed to solve a new type of problem and worked a few examples. The students were passive participants. During my action research, I became a gatherer of appropriate problems, an

observer and the person who asked leading questions. The students became the active participants and relied on themselves and each other and I became an encourager. I also ceased to be a rescuer of struggling students.

My first research question is *What will happen to the quality of student written communication and reasoning to solve problems after I spend time regularly teaching problem solving strategies?* I found the students became more comfortable writing their solutions and more adept figuring out which strategies were reasonable. I began presenting problem solving strategies and problems for the students the first week of February, 2008. When I asked the students to write a paragraph explaining their work and thought process, they wrote only two or three sentences. Mary[1] wrote the following paragraph on February 4, 2008. "I figured how many extra points from each game that there was. I took 26-1, and 30-5 and that got me 6 points altogether." On February 28, I received the following paragraph from the same student: "I took 5 * 205 to get how many pounds of garbage per day. Then I took that answer which was 1025 time 365 days to get how much garbage in a year. That gave me 374,125 pounds of trash. Then I divided by 2000 which is how many pounds are in a ton and I got 187.0625 tons." Although this explanation is still not well-written, it explains why the numbers were used. One can almost tell what the problem presented was by this solution. In the first explanation it is difficult to tell the question asked and if the solution is correct.

In the original interviews I conducted, all students were asked to solve two problems and write a paragraph explaining their solution. The paragraphs were rather sketchy. Joseph wrote, "I took $6.50 times 3 and $6.75 times 2 and added $49.50 and got $95.50. Finally I took $100.00-

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[1] All names are pseudonyms

95.50 and for my answer I got $4.50." I had all the students solve the same problems during the final interview. In the second interview he wrote, "I took $16.50 times three for the shirts and $6.75 + $6.75 to get two ties and then I added $49.50 + $13.50 + $32.50 for the jacket and got $95.50. Finally, I subtracted $95.50 and $100.00 and I got $4.50." This explanation still lacks some information, but it includes more of the information from the problem.

In my teacher journal on February 21, I noted that a student asked, "Do you want us to write a paragraph to explain our answer?" This was amazing because, less than a month earlier the students did not know how to begin writing a paragraph explaining their solution. Written solutions are becoming more complete as the students practice them. March 3, 2008, I used the rubric to grade written solutions the students scored two of four points for "explanation of thought process and solution." April 1, 2008, all seven students scored either three or four points in the same category. The problems were similar because both pertained to area and perimeter. I feel this is important, as when they write down their explanations they are required to slow down and think about what they are saying and doing.

All students were surveyed at the beginning of my action research project. Students were asked to respond to the following statement. "I like to write out explanations of how I solve problems." Six of the seven students disagreed with the statement. The students were asked to respond to the same statement April 30, 2008. Two students agreed with the statement at that time, three were neutral, and two still disagreed.

Students also became more aware of strategies available and which strategy might be of use for any given situation. My teacher journal entry February 13, 2008 stated, "Student effort was minimal, they do not seem to know where to start." Another entry from April 7, 2008 stated,

"Different strategies were used. Some drew a picture, but Joseph used a ratio box." I saw great growth in student strategy use during this project.

Students were interviewed in February. Each student was asked, "What strategies do you use when solving a problem?" The students listed trial and error, make a list, draw a picture and guess and check. When the students were asked the same question in May, ordered list, using a ratio box, look for patterns, and mental were added to the list. This provides additional evidence that students grew in the area of strategy usage in solving problems.

Student work became more efficient as the students practiced problem solving. Jerry, on February 12, 2008, asked if he could draw a court when the problem was about basketball. Later that class period, he realized it was of no use. The same student on February 26, 2008 drew a picture to figure how much paint would be needed to paint a room. Without the picture the student wanted to use volume not surface area.

Thus, these examples from my personal journal, student interviews, and the student survey all support my assertion that students became more comfortable in writing solutions to problems, and also expanded their repertoires of reasonable strategies. Through learning additional strategies for solving problems, students then became more adept at choosing appropriate strategies for problems. Although not all students became enthusiastic about writing solutions, their solutions did improve in terms of clarity and completeness.

What will happen to the student willingness to attempt word problems if the word problems are about topics of interest to them? As the research project progressed, the topics of the problem solving activities varied. The students were much more focused on problems that were pertained to topics of interest to them. Some of the activities were geared to be about topics of interest to the students. For instance there were problems about how to score 15 points in a

basketball game, fencing a pasture, police chasing a robber, etc. Other problems were generic in their topics as what are the length and width of a rectangle with a given area, what are the next numbers in a sequence and what is the rule for the pattern. Entries in my teacher journal show student effort varied greatly. On February 13, 2008, I noted, “Effort was minimal, they could see no relevance to the problem.” Two days earlier in my journal the students were to make $.50 with nickels, dimes, and quarters. I stated, “All students worked hard. However, there is no order to many lists.” A similar problem involving scoring fifteen points in a basketball game was given, and my journal states, “Kenny notices it is the same as yesterday’s problem.” Another quote is, “Joseph said to go in order, it is easier.” So, for word problems students found interesting, they worked hard.

On March 11, 2008, the students were told a car’s odometer was a palindrome and two hours later it was another palindrome. The comment in my teacher journal is, “Lacked effort, even after we discussed what a palindrome is.” Although I thought problems about cars would be interesting to students, this did not seem to be the case. As I observed the students while they were working on problems throughout the semester, my journal mentioned many times about the effort expended on the problem at task. Often, if the problem was of interest to them, my comment was that the effort was good that day.

One question on the student interview asked, “Are you willing to work harder on problems that are about a topic of interest to you?” All seven students responded, “Yes.” The students’ reasons varied.

Joseph: “It makes it easier.”

Roger: “It is something that I like.”

Mary: “It makes the problem more fun and interesting.”

So, while they gave different reasons, students all agreed problem solving was easier when the topic was more interesting to them.

The students were asked to solve two problems during the pre-research and post-research interviews. One involved having cartons full of boxes of pencils and trying to find the total number of pencils. The other problem involved buying clothes and figuring the amount of change one would receive. Both of these problems involved multiple steps. On the pre-research interview, six of seven students performed the correct operations on the money problem, and only four of seven performed the correct operations on the pencil problem. On the post-research interview, the results were similar. This time all seven students worked the money problem correctly, and three of the students omitted steps while working the pencil problem. My hypothesis was that the problem about change and clothing would be more interesting to students than pencils. Students overall were more successful solving the clothing problem than the pencil problem.

Overall, the student interviews and my teacher journal support my hypothesis that students would put forth more effort on word problems with topics of interest to them. Given the nature of our community, I developed problems related to teenagers, sports and farming to be interesting topics. I did notice students putting for more effort on the problems that they found more interesting.

As students worked on improving their problem solving skills, I wanted to know if it improved their mathematical communication with each other and with me. My third research question was *"What will happen to the quality of mathematical communication between students and student-to-teacher once students practice problem solving daily?"* Student communication improved as they practiced problem solving daily.

As students worked on the task for the day, I circulated throughout the room. Most days the students were sitting in groups of two or three. As I circulated, I heard comments like “I have the data in a table but I do not know what to do with it.” I also heard “do we multiply by 7.5 or divide by 7.5 to get the number of gallons in the pool?” Many times there were differing opinions, and strategies. As the semester progressed, the students became better at justifying their solutions to each other. Such as, we need to multiply by 7.5 because every cubic foot contains 7.5 gallons of water. Communication between students improved as the semester progressed. The students became more able to use correct terminology as well as better at explaining their reasoning and thought process.

One of my data collection devices was a rubric to score their written communication. The first few times I used the rubric, the students received one or two points out of four in the “Explanation of thought process and solution” row. In April, most students were scoring three or four points on that same row. The following table shows the progress in this area.

Student	Rubric 1 Perimeter	Rubric 2 Cartons	Rubric 3 Stereo	Rubric 4 Fertilizer	Rubric 5 Swimming
Joseph	2	1	3	3	3
Roger	2	1	3	4	3
Kenny	1	1	3	3	3
Ruth	2	1	3	3	3
Brad	1	2	3	3	4
Mary	2	4	3	4	4
Jerry	2	1	3	3	3

The rubric scores were chosen to be representative of the student data throughout the semester. Rubric 1 was in February, Rubric 2 and 3 were scores from March and Rubric 4 and 5 were from April.

Some days I presented problems that required an extended amount of time to solve. These problems offered the opportunity of extensive discussion among group members. One of

these problems involved the Fibonacci numbers and their squares. The students had a chart to complete. They were allowed to use calculators, which made the computation manageable. As I circulated the room I heard students comparing answers in different parts of the chart. I wrote in my teacher journal, “Even though they are using calculators, they are making computational errors.” I also heard much discussion on the findings of any patterns. I also wrote, “Students are having trouble finding patterns. This is causing much discussion among the students.” This discussion varied from group to group. The students worked on this problem for the entire class period and then presented solutions the next day. The presentations were followed by much class discussion. As I listened to the discussion, the students were being forced to know mathematical vocabulary such as squares, factors, and sum. Some students already knew the meaning of the words and others learned from their group members. They did not just ask me for the answer. This problem and the ensuing discussion demonstrate students’ increased proficiency with mathematical communication.

In the pre- and post-research interviews, each student solved a problem and explained to me orally what they did to solve it and why. The problem asked, “Each carton contains 288 boxes, with twelve pencils in each box; how many pencils are there in 56 cartons?” In the pre-research survey, I asked many questions to lead the students in their explanation. Joseph needed to be reminded that there were 56 cartons. He remembered there were twelve pencils in each box and 288 boxes in each carton, however, only found how many pencils were in one carton. I also asked why he multiplied. In the post-research interviews, the number of questions I asked decreased. The same student did not need prompts and he became more adept at explaining why he chose to multiply.

Overall, my teacher journal, student interviews, and student scores on the rubric all support my assertion that students increased their skills in mathematical communication. Rubric scores increased, and the amount of prompting I needed to do to encourage student written communication from the pre to the post interview decreased. Students became more skilled at explaining their reasoning while they were working in groups, as documented in my teacher journal.

My final research question is *"How will my teaching look when I spend more time teaching problem solving?"* My teaching will become more student-centered. The students relied less on me and more on each other. Prior to my action research, my eighth grade mathematics classroom involved presentation of new material to the class by me and extensive drill and kill for the remainder of the period by the students. When I started my action research in February, I would present a problem to the students and try to step back and let them work on their own or in a group. My teacher journal from February 7, 2008 states, "I am trying harder to step back and let the students struggle." My teacher journal from March 25, 2008 states, "Students had discussion among themselves about what installments are." After the first couple of weeks, I would present a problem to them, make sure they understood the problem, and I became an observer. The students became much more responsible for their work and their understanding of the problem. They began to rely on their classmates much more. Toward the end of the researching timeframe I wrote, "Good job of reasoning. Students worked hard and worked well together. Paragraphs are getting better, however some are still struggling putting thoughts into words." (Personal Journal, April 1, 2008)

Throughout the semester, we worked on various strategies. Some of these were drawing a picture, making an organized list, looking for patterns, and solving a simpler problem. My role

was to demonstrate and guide them through the process, but then I stepped back and became an observer and encourager. I also tried to ask leading questions.

Later in the semester, I observed students working on a problem and just relying on each other. During many instances, they did not ask me any questions. I also observed students becoming more self-confident. Students who, at the beginning of the research project, would automatically take another student's answer or explanation began to question the other students at more length. They began to think their answer was correct and discussed it with other students, as stated in my journal. "Students discussed well today, they are getting better at defending their answers." (Personal Journal, March 20, 2008)

The main challenge for me during this research project was to not be the presenter of knowledge all the time. Many times I had to just walk away from a group that was discussing a problem so I would not help them out. As the project progressed, we spent more time on problem solving activities and less on drill and kill assignments. The students realized many times that they needed to know how to find area, or multiply fractions, but we did not do twenty problems to practice this. The student had to remember how to do the math required to solve the problem. If a student needed help they could ask a group member, or look in the book for assistance. Students realized they need to know math because it is used in many different situations in real life.

Conclusions

I decided on problem solving as the topic for my action research because I thought it was important. It is important for students to be able to solve many types of problems. I found that practicing problem solving did indeed help students become better problem solvers. Practicing problem solving daily resulted in better mathematical communication and reasoning. Students

were willing to spend more time solving problems when the problems were of interest to the student. My students became more willing to spend time to figure out a situation and to write their solutions with explanations as the project progressed. My teaching became more student-centered as I made problem solving a focus in the classroom. As in the projects developed by Greeno (1997) and Campbell (2006), the students became better problem solvers and more in control of their understanding of mathematics required to solve any problem

Also, I think group work many times did enhance the understanding of the material. However, like Cobb (2001), I like to have each student write their own explanation and solution. Each student writing an individual explanation gave each student the chance to show they understood the situation and the chance to add a little of individual color to the explanation. As I read the many articles, I realized that curriculum does need to change. This was evident with Greeno (1997), Campbell (2006), and Stillman and Galbraith (1998). It is up to the situation and teacher how to change the curriculum. The main focus needs to be of interest to the students and of the appropriate difficulty level. In the above mentioned projects, curricula were designed to meet student needs and interest. Many of these were stand alone curricula, but sometimes one can enhance the current curriculum. I chose to enhance my current curriculum with problem solving activities. My role as a teacher changed dramatically. As was mentioned by Albert, Cobb, Stillman and Galbraith, and Greeno, the role of a teacher may change to gatherer of materials, mediator, or chooser of appropriate problems. The teacher is no longer just the dispenser of knowledge.

Implications

As a result of my study, I want to implement problem solving into all of my classes next year. This will result in students becoming active participants in their education. To accomplish

this, I need to find appropriate problems for each level. Since I teach classes ranging from lower ability seventh graders to trigonometry, this could be time consuming and challenging. However, to speed this process, I subscribed to *Mathematics Teacher* and *Middle School Mathematics*. I plan to use some of the problems from the calendars in these magazines. I have also been asking for suggestions of books that I could requisition for next year. I have accumulated many problem solving activities through years of teaching. My goal is to better organize them so they are easier to access. I plan to have a problem solving activity for each class at least two days a week next year. I would like to do a problem solving activity each day, but I am remembering being told to take baby steps.

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Appendix A

STUDENT SURVEY:

Please circle your choice of answer to each of the following: Use the following to choose your answer. **SA** (Strongly Agree), **A** (Agree), **N** (Neutral, neither agree or disagree), **D** (Disagree) or **SD** (Strongly Disagree)

1. I like math. **SA A N D SD**

2. I am a good problem solver. **SA A N D SD**

3. I like to present my solutions to problems in front of the class. **SA A N D SD**

4. It is important to know how to solve a variety of problems. **SA A N D SD**

5. Mathematics is important in every day life. **SA A N D SD**

6. Problem solving is fun. **SA A N D SD**

7. I like to write out explanations of how I solve problems. **SA A N D SD**

8. I like to work in groups. **SA A N D SD**

9. I use math in other subject areas. **SA A N D SD**

10. I give up easily if I can not figure out how to solve a problem. **SA A N D SD**

Appendix B

INTERVIEW QUESTIONS (pre-research)

1. How do you feel when you are solving a word problem? Why do you think that is?

2. Are you more willing to attempt to solve a word problem if it is about a topic of interest to you? Why or why not?

3. What makes problem solving easy or difficult for you? Why do you think that is?

4. What strategies do you use when solving a problem?

5. How much confidence do you have in your ability to solve word problems? Why do you think that is?

6. Why do you think I ask students to work on problems in groups?

7. Why do you think I ask you to solve so many word problems?

8. Please solve the following problem and explain to me your thought process as you work the problem.

Each carton contains 288 boxes, with 12 pencils in each box. How many pencils are there in 56 cartons?

9. Please solve the following problem, and write a paragraph explaining your thought process and solution.

Don bought 3 shirts for $16.50 each, 2 ties for $6.75 each and a jacket for $32.50. He gave the clerk $100.00. How much change did Don receive?

INTERVIEW QUESTIONS (post-research)

I will ask the same questions, however, the last two problems may change. They will be very similar, but different numbers. I will also add these two questions.

10. Why do you think I am focusing on having students write out solutions to word problems?

11. As I make plans for math class next year, what advice would you give me about word problems? Group work? Writing solutions?

Appendix C

PROBLEM SOLVING RUBRIC

Characteristics	**4**	**3**	**2**	**1**
Understanding of the problem	Relevant information identified and used correctly	Relevant information is identified, but not all of it is used correctly	Identified some of the relevant information, but missed some important t information. Not all was used correctly	Very little understanding of the problem was displayed.
Strategy chosen and applied	Correct strategy chosen and applied	Correct strategy was chosen, but was not applied correctly	Strategy chosen was not correct, but was some correct thought process, so was partially correct	Incorrect strategy and incorrect thought process. Very little effort.
Calculations performed	Correct operations are chosen and all calculations are completed correctly	Correct operations were chosen, but were minor errors in calculations.	Were gaps in the calculations shown. Those shown were correct.	Very few calculations were shown.
Explanation of thought process and solution	Use of correct mathematical terms and solution is presented in a clear, orderly manner so others can follow it	Explanation was correct, but lacked correct mathematical terms. Was presented in a clear, orderly manner.	The explanation has gaps, thus lacks important details.	Limited attempt at explanation. Huge gaps in the explanation.
Correct Answer	The solution is complete with correct labels.	The solution was complete, but lacked labels.	The solution was partially correct.	Incorrect solution.