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Using Non-Traditional Activities to Enhance Mathematical Connections

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Math in the Middle Institute Partnership
Action Research Project Report

in partial fulfillment of the MAT Degree
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Using Non-Traditional Activities to Enhance Mathematical Connections

Abstract

In this action research study of my classroom of seventh grade mathematics, I investigated the use of non-traditional activities to enhance mathematical connections. The types of non-traditional activities used were hands-on activities, written explanations, and oral communication that required students to apply a new mathematical concept to either prior knowledge or a real-world application. I discovered that the use of non-traditional activities helped me reach a variety of learners in my classroom. These activities also increased my students' abilities to apply their mathematical knowledge to different applications. Having students explain their reasoning during non-traditional activities improved their communications skills, both orally and in writing. As a result of this research, I plan to incorporate more non-traditional activities into my curriculum. In doing so, I hope to continue to increase my students' abilities to solve problems. I also plan to incorporate the use of written explanations of my students' mathematical reasoning in order to continue to improve their communication of mathematics

INTRODUCTION

The area of focus for my problem of practice was whether including more non-traditional activities in my curriculum would improve my students' understanding, retention, and connections of mathematical concepts. I was highly frustrated with students learning concepts for their daily assignment and test and then forgetting what they have learned because it had not become part of their mathematical schemas. Evidence of this frustration were junior/senior high students not being able to calculate fraction or integer arithmetic even though I knew quality time had been spent on those concepts in elementary school. Further evidence was my students' success, or lack thereof, in Algebra II because they did not retain information they had once "mastered" in Algebra I. Students came to me to express their frustration about Algebra II and I felt frustrated because I thought I did a good job in preparing them for upcoming challenges.

Including more non-traditional activities involved my teaching practice because it affected my curriculum. Non-traditional activities could also be used as a way to assess my students' understanding of the concepts. This type of assessment may actually mean more because students are applying their knowledge not their test taking skills. I had the ability to control my curriculum; therefore I had the ability to control the use of non-traditional activities in my classroom. There was not a time-table set by my district.

Students need to see the relevance of mathematics. Non-traditional activities could help students realize the relevance because they were connecting mathematics to something other than an assignment. When students see the relevance of mathematics, then they should be motivated to learn. In the past I have tried to incorporate non-traditional activities into my curriculum, but I was aware it is an area that I could improve on, especially incorporating quality activities that enhance student learning, not just fun activities.

In reflecting on my own understanding of the use of non-traditional activities, I believe learning should be hands-on. Sometimes that is a difficult thing to accomplish in mathematics. I felt students learn by participating not listening and mimicking. It is our goal as educators to create learners who can problem solve and create original ideas. Do we create those types of thinkers by forcing them to listen and do things exactly the way the teacher does? It was important to change the way I taught mathematics because in more advanced classes, students were having a difficult time building on concepts that I spent a great deal of time teaching. Obviously students did not truly learn the concepts. Would having an application of these concepts through non-traditional activities help students to remember and connect them to prior and new mathematical concepts?

This problem related to issues around reform in mathematics education because I wanted to improve my students' connections to mathematics. The National Council of Teachers of Mathematics (NCTM) stated that "thinking mathematically involves looking for connections, and making connections builds mathematical understanding" (NCTM, 2000, p. 274). The NCTM also stated that "instruction programs from prekindergarten through grade 12 should enable all students to:

- Recognize and use connections among mathematical ideas
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
- Recognize and apply mathematics in contexts outside of mathematics (NCTM, 2000, p. 274).

I wanted students to see how mathematical concepts are connected, as well as for students to see the relevance for the concepts they were learning in hopes that this would increase their retention

of these concepts. Mathematics in the real-world is not going to be twenty to thirty problems of a similar concept. It is going to be a problem and students are going to have to find a solution. It is important to practice the type of math students will be using as they become adults.

An ideal classroom is one that is student-led where students are motivated to learn because they see relevance for what they are learning. They see connections between concepts they have already mastered and to applications outside of the mathematics classroom. Students would work together to solve real life math problems. They would discuss with one another different strategies in solving the problem then use that justification to go about solving it. Students would be able to explain why they chose that strategy and why their answer makes sense. For example, students would not get hung up on a fraction that may not be easy to solve. They could see it in decimal form thus creating a much simpler problem. Students would retain the information they learned and would be able to apply it to new contexts and build upon it.

Many obstacles stand in the way of my ideal classroom. The fact that there are approximately twenty-five students in a classroom makes it difficult to get to student questions immediately. When students have to wait to have a question answered, they lose their train of thought and sometimes their motivation. The fact that we only see students for 50 minutes a day is also an obstacle. By the time students get settled in, there is about forty minutes before it is time to clean up; and that is on a good day where there were no interruptions such as students leaving early for an activity or a fire drill. Another obstacle is that there are only 180 days in a school year. Currently my school's curriculum is not aligned to the state standards. There is just not enough time in a year to teach that many concepts and connect students' knowledge through a non-traditional activity. These types of activities seem to take a week or two if done properly. For the non-traditional activities alone, that is 48 weeks in a 36 week school year. There is also

the pressure, especially in Algebra I, to get through the entire 600 page textbook so that students are prepared for Algebra II when they are expected to know all of those concepts. As you can see, there are many obstacles that stand in the way of my ideal classroom, the biggest one being time.

PROBLEM STATEMENT

The problem I investigated throughout the course of my research was whether including more non-traditional activities in my curriculum improved my students' connections of mathematical concepts. This problem was worth knowing more about for my own practice because if students could connect mathematical concepts to prior knowledge or to another context outside of mathematics classroom, then their ability to retain the knowledge should increase. Would non-traditional activities help students make these connections? Connections could be made by students if teachers could relate concepts or non-traditional activities taught previously. A seventh grade activity may build from an activity students did in fourth grade. An activity in Algebra II may build on an activity from Algebra I. Many teachers struggle with students making connections within their learning. If my school had non-traditional activities based on concepts for many grade levels and these non-traditional activities showed increased connection and retention of mathematics, we could share these ideas with a larger community of educators. Others could improve upon our ideas and share their successes that improved student learning.

Using non-traditional activities to connect mathematical concepts related to an important problem of practice because the goal of teaching is for students to retain what they are learning. Students retain what they learn if they can made connections between prior knowledge or to an experience. Including meaningful non-traditional activities in my curriculum helped students

create those connections thus improving their retention of knowledge. More importantly, the use of non-traditional activities gave students the foundation to apply their mathematical knowledge outside of the mathematic classroom. The practice to recognize and apply mathematics outside of the classroom helped students do so when they are no longer in the classroom, but still using mathematics.

LITERATURE REVIEW

Mathematics is difficult and tedious for many students because they do not see the connections in mathematics. In incorporating the use of non-traditional activities to enhance mathematical connections, I hoped to make mathematics become more attainable for my students. Themes discovered while reviewing the literature for my action research were mathematical connections, non-traditional applications of mathematics, communication of mathematical ideas, and problem solving in mathematics. These themes related to my research because I studied mathematical connections through the application of non-traditional activities. Within these activities, students were required to communicate, both written and orally, while solving different applications of mathematics.

Mathematical Connections

Mathematical connections are essential to understanding mathematics. Many reserachers I reviewed stated this idea. Richhart (1999) wrote an article about using big, generative topics to create connections between mathematical ideas. He wrote about the importance of finding the fundamental mathematical concepts and building connections around them. Richhart believed these changes had to be made in order to turn a fragmented curriculum of skills and basic facts into a coherent quest for understanding. He also believed that by opening up the curriculum

though big ideas, teachers would have the groundwork for building mathematical connections for their students.

Schroeder (1993) and Noss, Healy, and Hoyles (1997) discussed different types of mathematical connections. Schroeder investigated mathematical connections that seventeen tenth grade students used to solve non-routine problems. He found students had difficulty connecting the problems to mathematical concepts. Noss, Healy, and Hoyles researched the use of computer applications to generate symbolic representations of mathematical concepts. They studied two students, who were twelve and thirteen years old, using a computer program called Mathsticks. Noss, Healy, and Hoyles observed the students' processes through solving a problem. The observation occurred on a single day as the students went about solving the problem created by researchers. In these articles, the authors spoke of internal/intra connections and external/extra connections. Internal/intra connections are those connections formed between mathematical concepts. The NCTM connection standard that correlated to this idea was to "Enable all students to recognize and use connections among mathematical ideas" (NCTM, 2005, p. 274). External/extra connections are those connections formed between a mathematical concept and a real-life application. The NCTM connection standard associated with that concept was to "Enable all students to recognize and apply mathematics in contexts outside of mathematics" (NCTM, 2005, p. 274). Schroeder observed that mathematical connections, especially external/extra connections, were not obvious to students when solving non-routine problems. Noss, Healy, and Hoyles observed that mathematical meanings come from connections, both internal/intra and external/extra, and that the ways connections are built depends on the structures constructed around them.

Nicol (2002) conducted research with twenty-two prospective teachers who visited professions involving mathematics and science in hope that they would be able to create lessons for their classrooms that were related to real-life applications. Nicol found it was difficult for the prospective teachers to see the applications of mathematics at the workplace, making it difficult for them to create lessons around these applications. Nicol stated that students do not make mathematical connections because they were never taught where mathematics is actually used. “It is difficult to understand a mathematical idea until it is used and difficult to use a mathematical idea until it is understood” (p. 304). She concluded that there needs to be an integration of school, work, and mathematics to enable students to become mathematically literate. She also stated that if teachers are going to make the study of mathematics connected, they need opportunities to experience the connections and relevance of mathematics themselves.

In summary, to help students make mathematical connections, teachers must create structures that allow mathematical connections to be made. Richhart (1999) believed the way to create these structures were focusing on the big ideas of mathematics and building the mathematics curriculum around these ideas. Nicol (2002) believed that the way to create such structures involved integrating school, work, and mathematics. Schroeder (1993) and Noss, Healy, and Hoyles (1997) believed that mathematical structures could be created by the type of connections, internal/intra and external/extra, students were making. This is stating that educators have the ability to create the structures that students use to build mathematical connections. A structure that may help students make connections is the use of non-routine problems.

Non-Traditional Applications of Mathematics

Many researchers I reviewed also discussed different applications of mathematics. Schroeder (1993) and Noss, Healy, and Hoyles (1997) discussed internal/intra and external/extra connections. Others discussed the use of manipulatives and technology. Durmas and Karakirik (2006) wrote about the benefits of virtual manipulatives to increase mathematical understanding. They believed that these manipulatives would begin to teach students how to communicate their mathematical ideas. Durmas and Karakirik discussed the use of manipulatives to gain understanding by learning with models, using manipulatives to understand a mathematical concept. “The potential of virtual manipulative for improving the quality of mathematics education is very promising since everyday new non-traditional activities and websites are developed for designing virtual manipulatives for some area of mathematics” (Durmas & Karakirik, 2006, p. 6).

Other authors discussed the use of technology to make mathematical connections. Noss, Healy, and Hoyles (1997) used a computer program to incorporate visuals into every stage of an activity. In doing so, they hoped to make mathematics concrete and meaningful. They believed mathematical connections could be made through visible representations. They also believe that a challenge in designing mathematical learning environments is to make mathematical content visible to learners. Rider (2007) used graphing calculators to help students shift quickly between multiple representations of mathematics. The shift helped students to focus on the mathematical concepts at hand, not on creating the multiple representations, thus aiding students to gain understanding of the concepts. In Rider’s article, she wrote about the benefits of using multiple representations to connect mathematical ideas. “This could be used to highlight features of each representation and to illuminate invariance among them building students’ flexibility to move

between different representations” (Rider, 2007, pp. 498-499). She also discussed how the use of multiple representations helped students to see the flow of mathematics and increased their understanding.

Overall, the authors used a variety of non-traditional applications to increase student understanding of mathematics. Durmas and Karakirik (2006) used manipulatives to increase understanding, while Noss, Healy, and Hoyles (1997) and Rider (2007) used technology. Noss, Healy, and Hoyles focused on how technology can help aide in the visual representation of mathematics and Rider focused on how technology can aide students in using multiple representations of mathematics. In general, these non-traditional applications of mathematics were used to increase student understanding.

Communication of Mathematics

Communication of mathematics is very difficult for students. Students can apply the correct mathematical method, but cannot articulate the relationship in language. (Noss, Healy, & Holyes, 1997) Durmas and Karakirik (2006) discussed the use of manipulatives to teach students how to learn to model. Learning to model means that students use manipulatives to help explain their reasoning as a first step towards communicating mathematical ideas.

Pugalee (2001) conducted a study with twenty-nine ninth grade algebra students. The purpose of the study was to demonstrate the importance of writing in the mathematics curriculum. He found that writing provided the process for attaining essential mathematical skills and that written responses demonstrated mathematical reasoning of students. Pugalee believed writing in mathematics was important because it required students to reflect on their work and clarify their thoughts about their ideas. He also believed that communication played a vital role in developing an understanding of mathematics. Pugalee saw through his students’ written work

their problem solving processes and mathematical reasoning. He also stated that student writings provided an important source of information for teachers and assisted them in assessing how their students learn and think about mathematics.

Whether it be through the use of manipulatives, written explanations, or oral reasoning, communication is vital in the mathematics classroom. The NCTM Standards also discussed ideas about communication in mathematics. “In classrooms where students are challenged to think and reason about mathematics, communication is an essential feature as students express the results of their thinking orally and in writing (NCTM, 2005, p. 268). Noss, Healy, and Holyes (1997) identified that communication of mathematical ideas were difficult for students. Durmas and Karakirik (2006) suggested a first step in communicating mathematical ideas. This step was the use of manipulatives to aide students in the explanation of their mathematical reasoning. Pugalee’s (2001) research focused on the importance of writing in the mathematics classroom. He discussed the importance of writing to clarify students’ mathematical reasoning and also to give feedback to teachers about how students are thinking about mathematical concepts.

Problem Solving in Mathematics

A problem area in most mathematical classrooms is problem-solving (Schroeder, 1993). Schroeder (1993) noticed during interviews with students that they could not see mathematical connections until hints were provided. First, teachers must truly understand the mathematical concepts that are being taught. Then they can begin to devise challenging problems (Richhart, 1999). Mathematics is a systematic way of thinking that produces solutions to problems. Solving a problem means representing it so that the solution is clear to yourself and others (Durmas & Karakirik, 2006).

Leikin and Levav-Waynberg (2007) conducted a study with twelve secondary teachers to see if the teachers could create multiple methods to teach and solve mathematical concepts. Their findings were that teachers did not know more than one method to solve problems, thus hindering their ability to teach students to solve problems using multiple methods. Leikin and Levav-Waynberg discussed the use and importance of multiple solutions to solve problems as a way of becoming effective problem solvers. Noss, Healy, and Hoyles (1997) found that students were reluctant to use visuals to problem solve. They believed it was probably because students were never taught the importance of visuals or encouraged to solve a problem using more than one method. The NCTM Standards also addressed this issue. They stated the importance of students being able to “apply and adapt a variety of appropriate strategies to solve problems” (NCTM, 2005, p. 256).

In summary, Schroeder (1993) noticed that many students did not see the connections in mathematics that would aid them in problem solving. This was, in large part, due to the way students were taught problem solving. Leikin and Levav-Waynberg (2007) found that, when probed, teachers could not generate more than one solution to a given problem. Noss, Healy, and Hoyles (1997) found that teachers shied away from using visuals to teach problem solving. Richhart (1999) stated that before teachers can develop challenging problems to integrate into their curriculum, they must first understand how to solve the problem themselves.

PURPOSE STATEMENT

The purpose of this study was to discover if non-traditional activities improved students’ connections of mathematical concepts. I believe it is difficult for students to problem solve because they do not understand the connections of mathematics. The variables of ability to solve different applications of mathematical concepts, oral communication of mathematical concepts,

and written reasoning of mathematical solutions were examined in seeking answers to the following research questions:

1. What happens to my teaching when I include more non-traditional activities into my mathematics curriculum?
2. What will happen to students' abilities to connect mathematical concepts to other mathematical ideas after implementing non-traditional activities?
3. What will happen to students' oral communication of mathematical concepts after presenting the solutions to non-traditional activities?
4. What will happen to students' written reasoning of mathematical concepts after writing solutions to non-traditional activities?

METHOD

I collected several forms of data while conducting my research. Before every non-traditional activity, students completed a before journal where they were asked to apply their knowledge of the concept. Students had been given prior knowledge about the concept through a more traditional approach to learning, such as worksheets. Next students were given a non-traditional activity that gave them an opportunity to apply the concept they had just learned. Students worked in small groups while completing the activity. When finished with the activity, students were asked to give a written response, as well as, an oral presentation of their findings. To conclude each non-traditional activity, students completed an after journal. Student journals, written explanations, and oral presentations were all scored using the same rubric. (See Appendix A.)

Approximately two to three weeks after the fraction and area/perimeter activities, I conducted individual student interviews. In the interviews, I asked students to complete yet another application of the concept. During the interview, I asked students to explain their thought process while solving the application. After students had applied their knowledge of the concept

to the application, I asked a series of questions about the interview application and their thoughts about mathematics in general. I interviewed the same eight students for both interviews for a total of sixteen interviews. The eight students were comprised of two high-ability students, three average-ability students, and three lower-ability students. After each interview, I wrote a reflection. (Student Interviews, March 14-19, 2008).

The final bit of data I collected was my weekly teacher journals. At the end of each week, I sat down and reflected on what occurred that week in my classroom. Many times I jotted down an incident from my classroom that week and reflected upon it.

To organize my data, I put all student work into a box. As I scored journals, written work, and oral presentations on the rubric, I entered scores on a spreadsheet. I also kept all interview responses in the same box. When I finished each interview, I took ten to twenty minutes and typed up my thoughts from the interview. I saved all interview thoughts, as well as, teacher journals into a folder on my computer. Once I had all my data compiled into a single location, I could analyze it. To do so, I would look at each research question and reflect upon which data I thought answered the question. After I pulled out many sources of data for each research question, I began to make my assertions while looking at my evidence.

Since we were encouraged to wait until after the January workshop to begin our research, my first activity was planned to begin February 11. Due to my illness, student illnesses, and other school activities, I began my first activity on February 20. From that point on, I felt like I was playing catch up to get back on the schedule needed to fit in all of my research. Needless to say, I never did get caught up, so instead of incorporating six non-traditional activities into my research, I only had the opportunity to incorporate three. I had intended to have two technology

based, two manipulative based, and two real-life application bases activities. The three activities that were incorporated were two manipulative based activities and one of the real-life application activities. I began with my first before journal on January 17 and ended with my last interview April 14.

The main instrument I used to help myself with data collection was a rubric. (See Appendix A.) I used the rubric to score journal responses, written explanations, and oral presentations. Another instrument I used was a series of questions at the end of each interview to get feedback from students. Students were asked about the mathematics they used to solve the interview problem, as well as, their thoughts about mathematics in general.

FINDINGS

During the course of my action research, there was not an average day. It was more like an average cycle that occurred. At the beginning of each new concept, I would present the material in a traditional manner, such as worksheets. After the class had gone through the material in a traditional way, I would then give students a journal to assess their ability to apply the concept they had just learned. After the journal, the students would explore the concept more in-depth through a non-traditional activity. At the end of the activity, students were required to have a written explanation of what they learned and give an oral presentation to the class. Finally, I would give students a second journal to again assess their ability in applying the concept.

Question 1

The first research question I sought to answer during the course of my research was, “What happens to my teaching when I include more non-traditional activities into my mathematics curriculum?” I believed that as I included more activities, my teaching would move

away from teacher-directed worksheets to more student-directed problem-solving. The data I collected to answer this question was from my teacher journals. Because my approach to teaching mathematics changed, the type of learners I was reaching changed as well. More than just high-ability students were becoming confident about their mathematical ideas.

My first piece of data comes from a teacher journal entry written about the cylinder problem:

One young gentleman, in particular, did very well on the project. He is a very hard working and very intelligent. His home life is not the greatest. In fact during the past couple of weeks he has been taken out of his home and put into foster care. Anyways, this is a student who likes projects and is an average learner. He, by far and away, did the best, and this is really saying something because this class is very bright. When students were constructing 4 new cylinders, he was the only student who stated to me that "Height and circumference, switch them by folding in a different way." By that he meant in folding a piece of paper in different ways, you switch the height and the circumference of the cylinder. He was creating cylinders so fast. Not just any cylinders, he was being truly creative. Most groups were dividing the paper into halves to create new cylinders. He never did that, he cut up the paper into fourths both ways. By doing so, he had the next part done already. You could really see the confidence in this young man while he was doing the project. Normally, he goofs around and gets into trouble when we do projects, but not this time. I was happy to see his growth and also to see him flourish during such a tough time at home. I am going to write about his Part IV response quickly. They are simple and very easy to understand and yet they are very accurate:

1. Do cylinders with the same dimensions have the same volume?
No because some are big and some are long so that makes a different volume.
2. What is the sheet of paper represent in the cylinder?
The side of a cylinder.
3. What do the dimensions of the rectangle represent in the cylinder?
The height and circumference and that make the whole cylinder.
5. How did you go about finding the dimensions of your cylinder?
We cut the paper into 4ths folded them in half or a circle.

(Teacher Journal, April 2, 2008)

It was great during this activity to see a student who is not typically the strongest in mathematics have success. The cylinder problem allowed students to construct their own learning because they had to create cylinders that met certain criteria. It was a very open ended activity. Students could solve the problem in many different approaches and all be successful.

A second teacher journal entry written about journal responses is yet another piece of evidence:

Yesterday, we went over the before journal, kind-of. I asked the students to find the volume of a box, the dimensions of box twice its size, and the volume of a box twice its size. Students doubled all dimensions of the box just like they did in their journal, but as we continued to discuss two students kept insisting that the doubled volume needed to be 96. (Twice the original volume of 48). These two students are not the strongest in math. Their idea prompted an idea in the “smarter” students and the class began to figure out that they needed to double only one side. (Teacher Journal, April 4, 2008)

This class discussion was great. I basically set the students up for failure, then asked them what went wrong. I asked a question similar the before journal students had just completed. Students responded exactly as they did on their journal, doubling all three dimension of the box. When I asked them to find the volume of the new box they had created, students could see that the volume was not double the original box, but actually eight times as large. Students then worked together to discover why this happened and what the correct answer would actually be. The high-ability students did not get the answer right away and average-ability students needed others to help them communicate what was going on. The lower-ability students benefited as well because their peers were explaining and asking for help rather than me asking questions and attempting to explain what was occurring. By the end of the discussion, I could see that the use of non-traditional activities helped me to reach different types of learners.

Teacher journal entry about projects, journals, and activities in general:

Students were very willing (other than 2 girls) to participate in this project. I know at times they have drug their feet, especially about journals, but half of them are coming around and I think they are actually enjoying the journals and most of them jumped right into the activity with little to no help from me. They are beginning to stand on their own two feet a bit. (Teacher Journal, March 6, 2008)

During the course of my research I could see students' mathematical independence growing. I was shifting roles from the person who taught them math, to the person who helped them figure out math when they were having trouble.

My final piece of evidence is from student responses to the Fraction Interview question "What advise would you give me about teaching fractions for next year?" Five out of the eight responses suggested I use manipulatives and other non-traditional activities. These suggestions came from all ability levels, one from high-ability, two from average-ability, and two from low-ability.

Question 2

The second question I sought to answer through my research was "What would happen to students' ability of connecting mathematical concepts to different applications after implementing non-traditional activities?" While conducting my research I found that students' ability to connect mathematical concepts improved with increased application in problem-solving journals and non-traditional activities. The justification for this claim was supported through student interviews, student journals, and my teacher journal.

I conducted an interview about area near the end of the study with an average ability student. (See Appendix B.) After the interview, I wrote down the following thoughts.

Although she confused herself for a minute, the student knew how to find area, especially after I drew a rectangle and asked what the area was. I liked how she "completed" the rectangle and subtracted out extras. This was much easier than adding together all the small areas. She also got the length of the big rectangle was $4 + 13$ without a prompt. In the second figure, the student drew a line without a prompt (although not in the right spot). She knew she needed to cut up the figure somehow to solve it. With a prompt she was quick to find the height of the triangle. Remembering the formula was difficult for the student, she kept wanting to divide by 3 instead of 2 (I'm guessing b/c we just finished volume of cones and pyramids in class). Overall good knowledge. (Teacher Journal, April 1, 2008)

I found it very interesting that students solved the area problems using different methods. The student mentioned in this interview found the area of the large rectangle, then subtracted the area of the extra square. Six of the eight students cut up the rectangle then added the smaller shapes together to find the total area. Interesting enough five of the six students cut up the rectangle in different ways. Finally one student saw that you could cut off a square from the left side of the rectangle and put it in the right side to form a complete rectangle.

Several pieces of evidence were found in student journals. The very first before/after journal asked students to apply different uses of fractions and percentages. These journals came before and after the M&M activity in which students were asked to find the fraction and percentage of each color of M&M's in a bag and create a bar and circle graph based on their information. The before journals for the activity had an average rubric score of 4.72. The after journals for the activity had an average score of 6.06. This was an increase of an average 1.3 points on the rubric. Four of the eighteen students actually did worse on the after journal. There were a couple of outliers in the data. One student dropped 3 points. I believe this was due to poor attitude. Another student raised 7 points because they did not complete the first journal, again, due to attitude. If I threw out these extreme cases, the class average would have an increase of 1.1 points.

There was a student who improved her journal score by three points after the M&M Activity. In the before journal, the student stated that “75 *doesn't belong in group 1 and 200 doesn't belong in group 2*” (Student Journal, February 19, 2008). There was no explanation. In the after journal, the student stated “0.5% of 200 *doesn't belong in group 1 because there aren't using decimals in the percents. I don't think that 40% and 6 belongs because 6 should be 60*” (Student Journal, February 26, 2008). Although the after journal was still not scored

exceptionally high on the rubric, it did, however, show growth in the student's writing. In the before journal the student had no idea how to explain and in the after journal there was at least some explanation.

When looking at journal score average during the entire course of my research, I noticed that students were getting much stronger at applying and explaining mathematical concepts. In the students' first set of journals, where there was no activity between them, the average journal score dropped 3.45 points, even after discussing what a good response would look like after the first journal. On the next set of before/after journals, with the M&M activity between, the average journal score increased .94 points. For the third set of before/after journals, with the area and perimeter activity between the journals, the average journal score increased 2.18 points. Finally on the fourth set of before/after journals, with the Package Project Activity between the journals, the average journal score increased by 2 points. When I looked at the eight student journal throughout the course of my research, journal score averages were as follows:

Journal 1 (no activity): 7.18	Journal 5 (before): 4.88
Journal 2 (no activity): 3.72	Journal 6 (after): 7.06
Journal 3 (before): 5	Journal 7 (before): 7.47
Journal 4 (after): 6	Journal 8 (after): 9.47

Journal averages were getting much stronger. By the final journal, students were averaging 9.47 points out of 12.

My final piece of evidence comes from my teacher journal about fraction interviews.

Another point that came out is that some students just do not understand what a fraction is. When students had trouble and I asked them to model the fractions using dots, many struggled to represent $\frac{1}{6}$. They would get 6 dots of one color and 1 dot of another. This was from students who did quite well on the fraction standard. The interviews relate to my problem of practice because students are not making mathematical connections. They go through the motions, but they don't truly understand. It is my hope that my non-traditional activities will help students make these connections. (Teacher Journal, March 20, 2008)

After conducting the fraction interviews (See Appendix C.), only the two high-ability students were comfortable with their knowledge about fractions. When asked “Are you comfortable talking about your ideas in math,” one high-ability student stated, “*Yes, math comes naturally*” (Student Interview, March 19, 2008). The other six students really struggled explaining what a fraction was, let alone, locate it on a number line. When an average-ability student was asked the same question, her response was, “*Sometimes, if I know I’m right*” (Student Interview, March 20, 2008).

Question 3

My third research question was “What would happen to students’ oral communication of mathematical concepts after presenting the solutions to non-traditional activities?” To collect data on this research question, I scored student oral presentations about activities using my rubric (See Appendix A.), conducted student interviews, and kept a teacher journal. While conducting my research, I found that as students’ written communication of mathematical concepts improved, so did their oral communication. It appeared when students worked through any misconceptions or lack of understanding through a written explanation, they were better prepared to orally present their mathematical thoughts.

The first piece of evidence to support this claim is taken from my teacher journal about oral presentations.

Today we had our first oral presentations. I found them very difficult to assess based on my rubric. I’m used to a rubric that is generated for each activity. The general rubric was difficult. . . . I’m looking forward to reading the students’ written explanations. Hopefully I will be able to gain better understanding. (Teacher Journal, February 28, 2008)

The presentations mentioned in the journal were about the M&M Activity. Students wanted to discuss how they created their graphs instead of discuss the concepts of fractions and percents.

Before the presentations, I did not have a chance to look over student written responses. I changed this for the next presentations.

My next piece of evidence to support this finding is taken again from my teacher journal about the second round of oral presentations.

Oral presentations went much better this time. I believe they were because last night I read through the written explanations, so I had an idea of what the students were thinking. Then I made comments on what the students had written and gave them time today to fix what they were going to say when they presented. This helped not only me so I knew what to expect from the students, but also the students because they knew what I expected of them. All groups received 12 out of 12 on their presentations. I did question two groups about their statement that radius affects the volume. I asked how. One group said that the bigger the radius, the wider the cylinder. The other group said that you square the radius in the volume formula. (When I say group, I mean the strongest member of the group ☺) Both I thought were really great answers. I also liked that the second group did not copy the first groups' answer. (Teacher Journal, April 4, 2008)

I found that responding to students' written explanation before their oral presentations greatly improved the presentations given. The average rubric score for the first presentation was 7.44 out of 12. The average rubric score for the second presentation was 12 out of 12. The numbers speak for themselves.

My final piece of evidence for this research questions is take from my written thoughts after both the fractions and area interviews for a single low-ability student.

The student did a really nice job setting up the fractions using the dots, but she had a very difficult time deciding if they were closer to 0, $\frac{1}{2}$, or 1. She would have the right answer but really struggled with explaining herself. I thought she had a good grasp on what a fraction was, especially since she is a lower ability student. With her concept of fractions, I would say she interviewed more like the average ability students. . . The second shape the student was much quicker. She didn't know that the area of a triangle was $\frac{1}{2}bh$, but she quickly caught on once I drew a picture and cut the rectangle in half to make a triangle. The most difficult part again for the student was putting it into words. (Teacher Journal, March 31, 2008)

I found this entry interesting because it seemed to me the student had a very good understanding of the mathematics we were learning. I wondered if it was the mathematics that made her low-

ability or was she low-ability because she has difficult communicating her ideas about mathematics?

Question 4

The final research question I investigated during the course of my study was “What would happen to students’ written reasoning of mathematical concepts after writing solutions to non-traditional activities?” I found that students’ written reasoning of mathematical concepts improved due to practice, as well as, students’ written reasoning was clearer because they have the terminology and increased understanding gained through the activity. These claims are based on evidence from students’ written explanations of activities, student journals, and my teacher journal.

On the first written explanation students turned in, the M&M Activity, the average score was a 7. An example of this writing follows:

1. What is a fraction? *“A number over another number.”*
2. How do we find a fraction? *“The number of blues over the total of all the colors added together.”*
3. How do we calculate percents? *“Get a fraction divided the top by bottom and then move the decimal 2 to the right.”*
4. What is a percent? *“The number you get when you divide a fraction.”*
5. How are fractions and percents related? *“Because you need a fraction to get a percent.”* (Student Work, February 25, 2008)

On the last written explanation students turned in, the Cylinder Project, the average score was a 9. An example of this writing follows:

1. Do cylinders with the same dimensions have the same volume? Why or why not? *“Yes, because they have the same dimensions so you will come up with the same answer.”*
2. What is the sheet of paper represent in the cylinder? *“It represents the circumference and the height.”*
3. What do the dimensions of the rectangle represent in the cylinder? *“It represents all the sides.”*

5. How did you gob about finding the dimensions of your cylinder. “*We took 8.5 divided by 4, 5, 6, 7 and got that answer then 11 times 4, 5, 6, 7 to get that answer.*” (Student work, March 27, 2008)

In the first example of student written explanations, the reasoning is very short and not very clear. The student used fragment sentences and did not thoroughly explain their ideas. In the second example of student written explanation, the explanations are still not perfect, but the reasoning is clearer and the student used complete sentences.

My second piece of evidence comes from examples of student explanations from their after journals. (See Appendix D.) The first after journal about fractions and percents, the average score was a 6. An example of this writing was:

*Group 1 = .5% because it is the only one with a decimal in the percent
Group 2 = 4% because it sounds like a good guess and I don't get it.
(Student Journal, February 26, 2008)*

On the volume after journal (See Appendix E.), the third after journal, the average score was a 9.47. An example of this writing was:

In the one that I doubled one it can hold 10,560 and the one that I doubled 2 can hold 1,920 and when I double them all it = 3,840 and they way I did that is like all of them I doubled 8 = 16 then 10 = 20 and then 6 = 12 then I x 16 · 20 · 12 then I got 3,840.

$$0 \quad 8 \times 10 \times 6 = 480$$

$$\text{All} \quad 16 \times 20 \times 12 = 3,840$$

$$1 \quad 12 \times 8 \times 10 = 10560$$

$$2 \quad 12 \times 20 \times 8 = 1,920$$

(Student Journal, March 27, 2008)

As you can see students written explanations became much stronger during the course of my research. Students began to develop an understanding of how to explain their mathematical thinking. Explanations demonstrated students' thought process, not just their solutions.

Although explanations may have been minimal or confusing in the after M&M journal, all journals had an explanation. In the before journal, there were five journals out of eighteen that

had no explanation whatsoever. Eleven out of the eighteen students improved their explanation in the journal. Of the seven who did not, five of them are below average students who struggle with written language and two are above average students whose written explanation was strong in the beginning.

My final piece of evidence for this research question comes from an entry in my teacher journal about written explanations:

Journals seem to be getting much better. When we started, students had no idea what to write. Now, even if they don't know how to solve the problem, they try it. Explanations are slightly better, but they still have a long way to go. I'm really looking forward to the after area/perimeter journal. I have a feeling they are going to be great! (Teacher Journal, March 6, 2008)

While grading student journal explanations with the rubric, I could really notice students' mathematical writing beginning to develop, even over such a short period of time.

During my research, I discovered two themes while answering the question, "What would happen to students' written reasoning of mathematical concepts after writing solutions to non-traditional activities?" The first theme I discovered was that students have a better idea how to explain their mathematical reasoning because they have had practice writing explanations, had seen examples of others' written work, and had been given opportunities to rewrite their own work. The second theme I discovered was participating in activities and discussions with a partner was deepening the students' understanding of the concept, thus increasing their ability to explain their reasoning.

CONCLUSIONS

My findings said many things to me as a teacher. First, and most importantly, my research showed that the use non-traditional activities helped me to reach more of my students. The more traditional approach to teaching mathematics was geared towards students to whom

mathematics came easy. Learning a new concept everyday and moving on to another was not working for many of my students. By organizing my activities around a central idea, as suggested by Richhart (1999), and connecting the concept to multiple applications has helped me to reach many more types of learners. The reason I was reaching more types of learners was the non-traditional activities helped different students make connections in their learning. Seeing the concept in multiple applications gave them more opportunities to connect with what they were learning.

Another finding I found to be important was the more opportunity I gave my students to practice problem-solving, the better they got at applying and connecting their knowledge to different applications. Similar to the findings of Schroeder (1993) and Noss, Healy, and Hoyles (1997), at first connections, both internal and external, were difficult for students. As students were given more opportunities to practice applying their knowledge through journals, activities, and interviews; the stronger they became at applying their knowledge.

Not only did my students' ability to problem-solve increase, their ability to explain their reasoning while problem-solving increased as well. My students' mathematical reasoning improved through writing explanations and interactions with their peers. Writing explanations helped my students explain their reasoning because writing is an important tool to aide students in reflection of their work and gives them a chance to clarify their thoughts, as stated by Pugalee (2001). As students written explanations improved, so did their oral communication.

Durmas and Karakink (2006) suggested that manipulatives were a good stepping stone to get students communicating about their ideas. I used this idea during my fractions interview. When students were having difficulty explaining or even understanding a question about fractions, I encouraged them to use a manipulative. While using the manipulative, students

reached a better understanding of their thoughts and could more thoroughly explain their thoughts to me. The manipulative seemed to give them a starting point in the explanation.

IMPLICATIONS

As a result of my research, my classroom practice will change in future years. First of all, I intend to use at least one non-traditional activity to help students make connections among concepts learned during each big mathematical idea. I will do so because I believe these activities helped my students to see not only the relevance of mathematics, but also helped them to create connections between the concepts themselves.

I will also use more manipulatives in my classroom to teach mathematical concepts to my students. I have learned manipulatives not only help student model to learn, but also learn to model as a way of communicating their mathematical ideas. To communicate ideas, students must truly understand concepts. Using manipulatives is an effective way for students to begin communicating mathematical concepts.

Finally, I will continue to have my students apply their mathematical knowledge using journals. I have found journals have not only made my students stronger problem solvers, they have also increased my students' ability to explain their reasoning. Students went from writing no explanation for their thoughts to writing a full page of explanation in a matter of six weeks. Imagine what student written explanations will look like if they continue working on this skill for an entire year.

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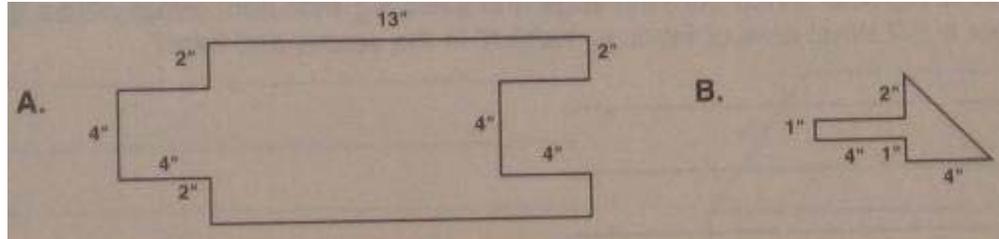
APPENDIX A

	4	3	2	1
Accuracy	Response was accurate	Main ideas are accurate, but some minor inaccuracies	Minimal accuracy	Response is not accurate
Terminology	Terminology used and used correctly	Some use of terminology or a few errors in terminology	Attempted, but not used correctly or minimal use of terminology	No use of terminology
Explanation of mathematical thinking	Explanation was thorough, clear, and easy to understand	Explanation was not thorough or lacked clarity	Explanation is minimal and/or very confusing	No explanation given

Created by Stacie Lefler, *Writing in a Mathematics Classroom: A Form of Communication and Reflection*

APPENDIX B

Area Interview



Please explain how to calculate the area of each shape.

In addition to interview problems, ask students the following questions at the end of each interview:

1. What math ideas did you use to solve the problem?
2. Are there related math ideas that would help you solve the problem? How are these ideas related?
3. What math terms did you use to explain the solution to the problem?
4. Are you comfortable talking about your ideas in math? Why or why not?
5. What do you like best about math?
6. What do you like least about math?
7. What advice would you give me about teaching (fractions/area) for next year?

APPENDIX C

Fractions Interview

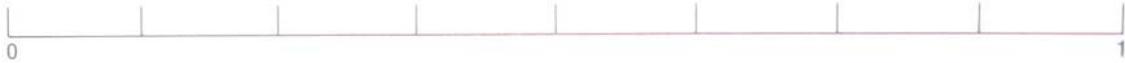
State whether each fraction is closest to the benchmark 0, $\frac{1}{2}$, or 1.

Fractions: $\frac{1}{6}$, $\frac{7}{8}$, $\frac{3}{5}$, $\frac{2}{9}$, and $\frac{11}{10}$. Please explain your reasoning.

For each number, write it at the appropriate place on the number line:

Fractions: $\frac{3}{3}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{16}$, $\frac{16}{16}$

Explain how you located the points on the number line.



In addition to interview problems, ask students the following questions at the end of each interview:

1. What math ideas did you use to solve the problem?
2. Are there related math ideas that would help you solve the problem? How are these ideas related?
3. What math terms did you use to explain the solution to the problem?
4. Are you comfortable talking about your ideas in math? Why or why not?
5. What do you like best about math?
6. What do you like least about math?
7. What advice would you give me about teaching (fractions/area) for next year?

APPENDIX D

After Journal – Decimals, Percents, and Fractions

In each group, state which one does not belong. Explain your reasoning.

Group 1: 75% of 120; $\frac{3}{4}$ of 12; $\frac{3}{4}$ of 120

Group 2: $66\frac{2}{3}\%$ of 300; $\frac{2}{3}$ of 300; $\frac{3}{2}$ of 200

APPENDIX E

After Journal – Volume

The Standard Box Company makes boxes based on a “standard box” which is 8” by 10” by 6”. The “standard box” holds 480 cubic inches. How much will a box with (a) one dimension doubled; (b) two dimensions doubled; an (c) all three dimensions doubled hold?

AUTHOR NOTES & BUDDY RESPONSES

1. This research paper explores the findings of my research for me to better reflect on what my findings were and what I can learn from them.
2. This is my first draft. Many things I have copied, pasted, and changed from previous documents. The abstract, methods, conclusion, and implications are new.
3. I am very unsure about what I have written. It was VERY difficult for me to write this paper, that is why most of it is copied and pasted from other papers. I found writing this paper to be very over-whelming. I know my method needs a lot of work. I haven't yet attached my appendices. My abstract, conclusion, and implications maybe weak as well. The paper in general may be too long because I did borrow many parts for previously written papers.
4. I have proof-read the paper a couple of times myself. I was hoping to have my mom, the proof-reading genius, read it, but I haven't gotten that far as of yet.
5. I apologize that it is so long. I'm looking for the most response to the methods, conclusion, and implications sections. Do they make sense? Can you understand what I am trying to say?

AUTHOR'S RESPONSE TO BUDDY NOTES

1. The biggest change that was made in my research paper was transition to findings into paragraph form. I didn't have the energy when posting my Buddy's copy, but this time, with Leah's help, I got it done.
2. The biggest concern again was transitioning the findings sections into paragraph form.
3. As always Leah had very helpful suggestions on how to re-word things so that they made more sense. I get my biggest suggestions from actually reading Leah's work. I get so many ideas seeing what she has written.
4. I'm not sure what the strengths of my paper are. I still feel it is a work in progress.
5. I love working with Leah, she is a 10!