7-2009

The Role of Manipulatives in the Eighth Grade Mathematics Classroom

Michaela Ann Goracke
Harvard, Nebraska

The Role of Manipulatives in the Eighth Grade Mathematics Classroom

Michaela Ann Goracke
Harvard, Nebraska

Math in the Middle Institute Partnership
Action Research Project Report

in partial fulfillment of the MAT Degree
Department of Mathematics
University of Nebraska – Lincoln
July 2009

The Role of Manipulatives in the Eighth Grade Mathematics Classroom

Abstract

In this action research study of my classroom of eighth grade mathematics, I investigated the use of manipulatives and its impact on student attitude and understanding. I discovered that overall, students enjoy using manipulatives, not necessarily for the benefit of learning, but because it actively engages them in each lesson. I also found that students did perform better on exams when students were asked to solve problems using manipulatives in place of formal written representations of situations. In the course of this investigation, I also uncovered that student attitude toward mathematics improved when greater manipulative use was infused into the lessons. Students felt more confident that they understood the material, which translated into a better attitude regarding math class. As a result of this research, I plan to find ways to implement manipulatives in my teaching on a more regular basis. I intend to create lessons with manipulatives that will engage both hands and minds for the learners.

Introduction

This study on manipulative use in the eighth grade classroom attempts to investigate the question, “do manipulatives really work?” Specifically, does the use of manipulatives improve student attitude toward mathematics, is there a greater understanding of mathematical concepts when using manipulatives, and how does the use of manipulatives affect my teaching?

For the past two years, I have used manipulatives, but not as much as I would like. I have resisted incorporating them because I have often wondered if using them really does benefit student learning. So far this year, I have made little effort to use manipulatives. It takes quite a bit more time. Not only does it take extra time in the planning stages, but it takes time explaining how they work and what all the pieces mean. In addition to time, there are the students who are not abstract learners, so I go back and teach the concept with numbers and variables.

Since manipulatives are hands-on tools that help students create understanding of mathematical concepts, they are highly encouraged by the National Council of Teacher of Mathematics (NCTM). In the Principles of the NCTM (2000), this is explained: “Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge” (p. 20). The use of manipulatives also provides equity in the classroom. Not all students benefit from the same type of instruction. Many students benefit from hands-on cooperative learning, which manipulatives provide. This educational opportunity helps students develop understanding with different teaching strategies.

This equity in the classroom is very important to me, especially when I consider the demographics of my school. The town population is around 1,000 residents. The main source of income for the families of this community is agriculture-related. If the source of income for the families does not come from farming, parents commute to nearby towns for work. The school houses kindergarten through twelfth grade, with a total population of 256 students. Within this population, 60% of the students receive free/reduced meals and 22% of our population is students who receive Special Education services. We also have a 32% Hispanic population with 8% of those students identified as English Language Learners (ELL). The school also has a 15% population who are identified as High Ability Learners. This wide range of needs and abilities makes it essential that I use multiple teaching strategies so that all students have the opportunity to be successful.

With such a diverse population, it is imperative that I find teaching techniques that will benefit all of my students. Manipulatives was a course of action that I wanted to try to see if it made a difference for my students. I thought that using manipulatives would give all my students the opportunity to gain valuable insights and help them make connections that they may not get from a direct teaching method.

Problem Statement

The use of manipulatives has long been a source of controversy in schools across the country. Does the time it takes to prepare for, use and create the transfer of knowledge from manipulatives to understanding of concepts benefit student learning? With the demands placed on teachers to get further in curriculums many teachers skip the manipulatives and go straight to direct instruction. There is also an argument that many teachers do not know how to use the manipulatives to teach concepts that would benefit student understanding.

Even though there seem to be differing opinions, there are several reasons why manipulatives have a place in classroom instruction. First, student understanding rises. When students have the ability to build their own knowledge, and use tactile tools, students are more involved. When students are actively engaged in the lesson, the students’ stake in learning increases and their understanding of the concept is heightened. They may question what is happening, but that questioning leads to understanding. Understanding leads to academic achievement, which is the second reason why I believe manipulatives are important. When students understand mathematical concepts, it is implied that achievement scores increase. Furthermore, the quality of connections that students can make is deeply rooted in understanding.

Literature Review

Many teachers do not have the mathematical understanding (Moyer, 2001), or time (Eastman & Barnett, 1979) to construct manipulative activities so that students can develop their own understanding of a concept. This has led to guided learning with concrete objects, or not using them at all. What makes manipulatives such a controversy is that studies within the past 30 years have had differing outcomes with regards to the effects of manipulative use on academic achievement, the quality of connections made between mathematical content and manipulatives, and student understanding.

Academic Achievement

Academic achievement is the least controversial theme discussed throughout research done with manipulatives. Eastman and Barnett (1979) reported on a study that was designed to investigate whether pre-service elementary teachers could learn mathematics better using a pictorial approach or a hands-on approach. Their study showed that there was no significant difference on a test requiring manipulation of objects; however, there were significant differences when a concept-based test was administered. The experiment concluded that it may be necessary to use manipulative materials when working with basic whole number systems.

How much and how often are questions that seem to be topics of conversations when teaching using manipulatives. Looking at studies similar to Eastman and Barnett's (1979), Sowell (1989) took the results from 60 different studies on the effectiveness of manipulative use. She found, through the use of meta-analysis, that the longer a treatment was administered the greater student achievement was found to be. There was not mention of frequency of use within the study.

Moyer (2001) worked on a study that included five teachers’ use of manipulatives in their classrooms over the course of a year. The teachers included in the study reported to the researcher on a regular basis what types of manipulatives were used for what concepts, and how often they were used. The researcher also observed the teachers in their classrooms as well. Moyer stated that, “students who use manipulatives, outperform those that do not” (p. 177).

Another interesting point made is not only does the teacher experience play a large factor in academic achievement when manipulatives are involved, but also teacher attitude and perception as well. Moyer (2001) found that teachers’ conceptions of mathematics are grounded in their understanding of the content of mathematics. She also found that while each teacher was given training on how to use the manipulatives, they did not deviate much from the “typical” script found in the United States (p. 190). “Yet even if teachers have learned appropriate strategies for using manipulatives, their beliefs about how students learn mathematics may influence how and why they use manipulatives as they do” (Moyer, 2001, p. 178).

While all the researchers examined here found that the use of manipulatives increases student achievement, there are differences that make the results more interesting. One of those distinctions is that each study is focused around a different population, including kindergarteners, middle school students, and pre-service educators. Another glaring difference was that Moyer's

(2001) work focused on the role of the teacher and teacher attitude and beliefs. While Sowell (1989) focused on student achievement, Eastman and Barnett (1979) were attentive to the hands-on approach versus a pictorial approach. With Moyers' (2001) study, the teachers who had greater experience and education in mathematics were more confident in their understanding of mathematics and therefore had students with a higher level of achievement. Finally, the last of the differences among the studies was the length of time the treatments were in place, a factor affecting achievement according to Sowell's (1989) meta-analysis. In conclusion, students who were taught mathematics using manipulatives by teachers who were trained and believed in the theory of manipulative-use achieved greater scores than their counterparts who were not taught using manipulatives.

Effects of Understanding

Piaget (1952) suggests that "children do not have the mental maturity to grasp abstract mathematical concepts presented in words or symbols alone and need many experiences with concrete material and drawings for learning to occur" (as cited in Moyer, 2001, p. 175). Sowell's (1989) meta-analysis suggested that manipulatives had a better outcome for students at a young age than those who were older. The older students were better able to comprehend more abstract concepts, and manipulatives were not a necessity for these students' mastery of concepts. This was validated in an article by Lappan and Ferrini-Mundy (1993) that discusses a new vision for middle school mathematics curriculum. They agree that "as students move through the middle grades, their intellectual development is characterized by transition from a concrete-manipulative stage to abstract thought" (Lappan & Ferrini–Mundy, 1993, p. 627). Even though middle school students are moving out of the concrete stages of learning, students still "prefer active learning situations" and perform better because of the social aspect to it (Lappan & Ferrini-Mundy, 1993, p. 627).

Moyer (2001) states, "because students' abstract thinking is closely anchored in their concrete perceptions of the world, actively manipulating these materials allows learners to develop a repertoire of images that can be used in the mental manipulation of abstract concepts" (p. 176). However, Moyer warns that in order for students to effectively use manipulatives there must be tools that are readily available for them. She suggests that students must be able to seamlessly and automatically be able to use them without thought of what each tool does and how it works, otherwise the learning that is taking place is not about the mathematical concept but how the tool works.

Similar to this belief, is that of Clayden, Desforges, Mills, and Rawson (1994), who wrote an article focusing on authentic learning. They point out that "young children focus on the working practices of their activities. . . In their efforts to make sense of their classroom experience, the working practices are much more salient than abstract ideas." An example of a "working practice" was a child coloring a picture of a concept. When asked what was learned, the child responded with, "coloring." These are examples of students not making connections. The connection between the task at hand and the "big picture" was not set for the student.

Green, Flowers, and Piel (2008) conducted a survey which ran treatments on 53 undergraduate students teaching mathematical concepts using manipulatives and picture drawings. The findings suggest that a small amount of time that includes "appropriate manipulative-based problem solving can produce powerful educational benefits." The authors believe that the active use of manipulatives was critical to their reconstructions of the concepts.

They believe that learning with manipulatives is correlated positively with later development of mental mathematics (p. 235).

Contrary to the beliefs Green et al. (2008) are the findings of Outhred and Mitchelmore (2000) whose study focused on “Rectangular Area Measurement” and pictorial representations of area. They found that that the uses of manipulatives when finding the area of a rectangle were not effective. They did find, however, that over time students’ drawings became more and more abstract as they began to master the concept of area. The authors concluded that the improvement in the drawings represented understanding and the ability to transfer connections. This introduces the idea of using pictures and drawings as a form of manipulatives that could increase student understanding.

The research gathered here suggests that the younger students are and more often manipulatives are used in a classroom environment the more benefits from understanding will occur. As students get older, their abstract thought processes develop. Consequently, they may not need to have physical tools to help them develop their understanding, but they still enjoy the activeness and possibly the social part of manipulative activity.

Quality of Connections

Probably the greatest concern teachers have when taking the time to create and teach a lesson using manipulatives is, “will students make sense of it?” The results of this question, according to research, vary greatly. The “mere presence of manipulatives does not assure that a connection will be made; they are not magic” (Moyer, 2001, p. 176). The mathematics must be “embedded in the task, and the task must be mathematically connected to students’ prior learning and to what the teacher wants them to learn” (Lappan & Ferrini-Mundy, 1993, p. 627). If teachers do not make the task meaningful, students will have a harder time making the connection between the task and the concept, and will see the activity as merely fun instead of learning. However, "young children often have difficulty generalizing knowledge and skills learned in the classroom" (Clayden et al., 1994, p.165). Helping young learners make a connection is the challenge that teachers undertake when using alternate teaching strategies.

This is reiterated in Meira's (1998) study that looked at student understanding in regards to transparency of manipulatives. Meira's study used three different manipulatives. The participants were seventh and eighth grade students who volunteered to problem solve. This study observed that while students did not necessarily know how to use the number machine, they were able to be more successful with this tool because they could relate it to previous classroom experiences with functions. From this, Meira analyzed that, "instructional devices might themselves become the motive of much wondering and conversation in the context of which students engage in mathematical activity" (p. 139).

Is seeing how they work just as good as doing? Those who merely watched how the manipulatives worked completed their work faster, as they were not bound to using the manipulatives (Eastman & Barnett, 1979). This idea is reiterated in Moyer's (2001) study that images alone helped students solve problems quicker. Demonstrating may not allow students to develop their own understanding, however it does allow for another mode of instruction that is time efficient. It also encompasses an experience for students to anchor information for the sake of prior knowledge.

In addition, Moyer (2001) and Sowell (1989) both mentioned concerns that the lack of teacher experience causes a loss of connection between manipulatives and concepts for students. This is echoed in a study by Kyriacou (1992) on Active Learning in the secondary school. In this study, Kyriacou sent questionnaires to math department heads asking them to rate their institution regarding teaching strategies. He found that the majority of the upper level grades primarily used a direct teaching approach, while the elementary grades tended to use activity teaching strategies more. He also found that a major problem faced by schools, is that "staff is not qualified to teach mathematics" (Kyriacou, 1992, p. 316).

An interesting approach that has yet to be mentioned is that of Noble, Nemirovsky Wright, and Tierney (2001). In a study about multiple environments and experiencing change, children did the same task but in different situations, essentially asking them to learn the same thing. It looked at student understanding from experience to experience. They suggest that students make connections based on their own experience of the world they live in (Noble et al., 2001). Therefore, no matter what the teacher's intentions are, each student will come away from the same learning activity with a different understanding based on the environment they live in and the experiences they have encountered.

All of the research certainly points to a concern of the quality of connections students make when using manipulatives in the classroom to a mathematical concept. Moyer (2001) found that students in her study had "fun" using manipulatives, but they were not doing "real math" when manipulatives were used. The manipulatives were not used in conjunction with the student's regular content, which Moyer suggests could have led to the lack of quality in connection of material.

Quality of connection to a mathematical concept is a delicate piece of the puzzle when planning and delivering lessons in which manipulatives are used. First, teachers may not have the mathematical understanding to create "real" experiences that are beneficial to student learning. Second, research shows that students develop their own understanding based on previous experiences which are unknown to the teacher and differ from student to student.

Literature Review Conclusion

All researchers agree that using manipulatives regardless of the length of time devoted to manipulative use is beneficial to some students' academic achievement. However, it is not clear how to help students make the connection between the active learning and the mathematical concepts. There are some researchers concerned that the lack of qualifications of staff plays a role in lower achievement for students (Kyriacou, 1992, p. 316).

The main difference between my study and those studies presented in this review is student attitude. I think that it is important to understand how students see themselves mathematically and how they feel about mathematics. The other studies contained components of attitude, but it seemed to be more of a byproduct than an intended study focus.

The age of my students is another difference. My study is composed of 19 students who are not grouped by ability. I have a diverse group of students. The seventh grade students that are in this class are considered to be in advanced placement, while the eighth grade students are considered to be at grade level or below. A couple studies used middle school students as well, but others included high school students, while one used kindergarteners.

Purpose Statement

The purpose of my study was to see if manipulatives really work in a middle school setting. From the previous research, it was shown that manipulatives are a preferred practice of learning by middle school students because of the socialization involved, but my concern was whether students could take away quality connections from the lessons. Specifically, I wanted to know what happens to the level of student understanding after a greater use of manipulatives was included in instruction. In the course of looking for student understanding, I also looked for changes in student attitude about mathematics. I was looking to see if a connection could be made between attitude and success. Finally, I looked at my teaching for differences in my attitude and effectiveness in instruction. The research questions providing focus for my study are:

- What happens to the level of student understanding after I implement greater manipulative use in the mathematics classroom?
- How do the attitudes of my students change when manipulatives are infused in the mathematics classroom?
- What does my teaching look like when I attempt to infuse more manipulative use into my classroom?

Method

I collected data for this study in the Spring Semester of 2009, from my eighth grade pre-algebra class. Several different forms of data were collected throughout the course of my study. First, I started with a pre-intervention survey (see Appendix A for a copy of the pre/post survey). I used this survey as a baseline measure of student attitude about success in the math classroom. From this survey I was also able to get an idea of what each student perceived as the purpose of manipulatives and if the activities were useful in their understanding of math concepts. This survey also gave insight into whether the student felt that they achieved mastery in a specific skill with the use of manipulatives.

I collected a total of eight weekly journals from students. The journals were usually written on Fridays following two to three lessons involving manipulatives of some kind. There were many different kinds of manipulatives used. We practiced graphing using pegboards, we used chips when working with integers, algebra tiles when solving equations and we also used protractors and compasses when Geometry was introduced. Before each lesson, students were taught how to use the tool or what each tile meant, hoping to alleviate confusion, so they could concentrate on meaning. In the journals the students were asked to reflect on their understanding, and also to express how they were feeling about math that week. These opinions and comments were organized and lumped together to gain information about the group instead of individual students.

I also conducted student interviews (see Appendix B for examples of questions). Students were randomly selected to participate in these interviews. I chose six students to interview regarding student attitude and six students to interview about understanding. The actual interviewing was spread out over the course of five weeks from March to April, 2009. It was difficult to schedule interviews with students, given the plethora of student activities, standards and other obligations that competed for time.

I collected student scores for a total of four tests, which were typically given every two weeks. I used these tests as a measure of mastery against what students said in their journals regarding the math concepts tested. I also collected my students' work daily in April, when the concept of adding/subtracting and multiplying/dividing polynomials was taught. This work displays students' understanding of how the manipulatives are used when working on the concepts. I used the tests to document when students used drawings or drawings of manipulatives to help them understand a question or to answer the questions.

Another form of data collection was my own journals. There are 13 journals that I used to address how the use of manipulatives affects my teaching as well as identifying student attitude changes and student understanding of content. The journals were written weekly, sometimes twice a week, depending on what I was learning, as well as how much time I found to write. Time seemed to be the biggest obstacle for me to overcome throughout the entire study.

As a final piece of the data collection puzzle, I used a post-intervention survey which was identical to the pre-intervention survey. I used this as my ending point on student attitude on April 17. It was also looked at to see if students had changed their opinions about their success in mathematics as well as their beliefs of mastery of mathematical concepts.

Findings

My classroom is organized in such a way that I have students sitting around six tables. Each group has three to four students working together. The groups are organized so that I had at least one student who traditionally performs well academically and then I filled in the remaining places with other students. When working with manipulatives, each table had their own peg boards, chips, rulers or whatever manipulative was to be used for the lesson to complete the group assignments. The overhead projector was used in the back of the classroom, while I had the SmartBoard at the front of the room to keep track of notes, ideas or hypotheses (see Appendix C for example of student work on SmartBoard).

I started each lesson with an explanation of what the manipulatives were, how to use them and in some cases what each part of them represented. For example, with the lesson on polynomials I took a whole day working with the tiles, drawing pictures, having students represent different expressions on the overhead and creating their own polynomials. When we found the formula for a cone and pyramid, the students first found the formulas of the square and the cylinder with sand as groups, before they were asked to solve for the cone and pyramid.

After the introduction of the manipulatives, I started with asking the students to try to solve a problem using the tools they had. I walked around the room asking questions and gathering information about what my students were learning. After I was able to visit almost every table, I asked students to either go to the projector or the SmartBoard to explain their answer and how they arrived at it. Usually, two or three students would want to share their findings (see Appendix D for student's representations of their work). This time gave the whole class the opportunity to evaluate their work and compare it to what others in the class had done.

Once each group was confident in how to use and solve the problems, I gave them four to five problems to solve independently. Again, I would walk around the room monitoring, and helping to answer questions and ask my own questions. These problems were harder than the first ones. My attempt here was to get students to take the knowledge they had already learned and apply it to another problem that was different, yet related. Usually these problems brought out some misconceptions. This allowed me to stop the whole group, discuss and redirect their learning.

Each night I would assign a few problems either from the book or problems that I created to check for understanding. Many nights, I asked students to either draw a picture of what was happening or represent it with manipulatives on their paper in some fashion. The students were given two nights to complete the assigned task. They were asked to bring up any questions the next day before I started the new lesson, so we could see if others were stuck. This allowed yet another opportunity to re-teach and redirect student learning.

Of course our daily routine did differ depending on the concept. When we did graphing and volume it was easier to walk around from group to group leading them to the next step since they were all in different places. When students lead their own learning it was interesting to see how far they could go, before they needed to ask questions for clarification.

The lessons that did not include manipulatives were not entirely different. When manipulatives were not used in my classroom, I spent the first 5-10 minutes having students share with the class problems they encountered while practicing their homework. Other students would share their solutions or echo the same problems. If the entire class was struggling with a concept, I would step in and explain what the problem was asking for. Then let them work it a little bit before continuing on with the lesson.

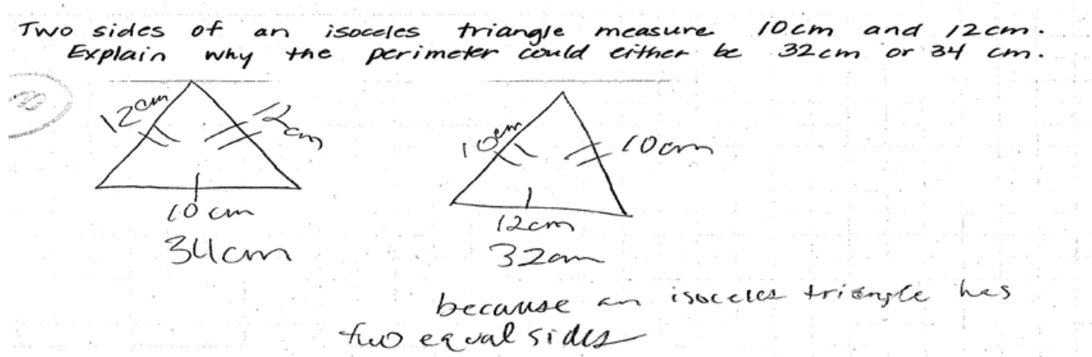
After this, we discussed the new topic for the day. When we see it and how the concept is used in our world. After beginning the lesson, I stopped to check for understanding along the way. Students would go to the board to solve problems, work as teams or groups to solve them as well. I find that using the team approach takes the pressure off, if they are uncertain how to solve the problem. When the guided practice was completed I assigned problems for independent practice.

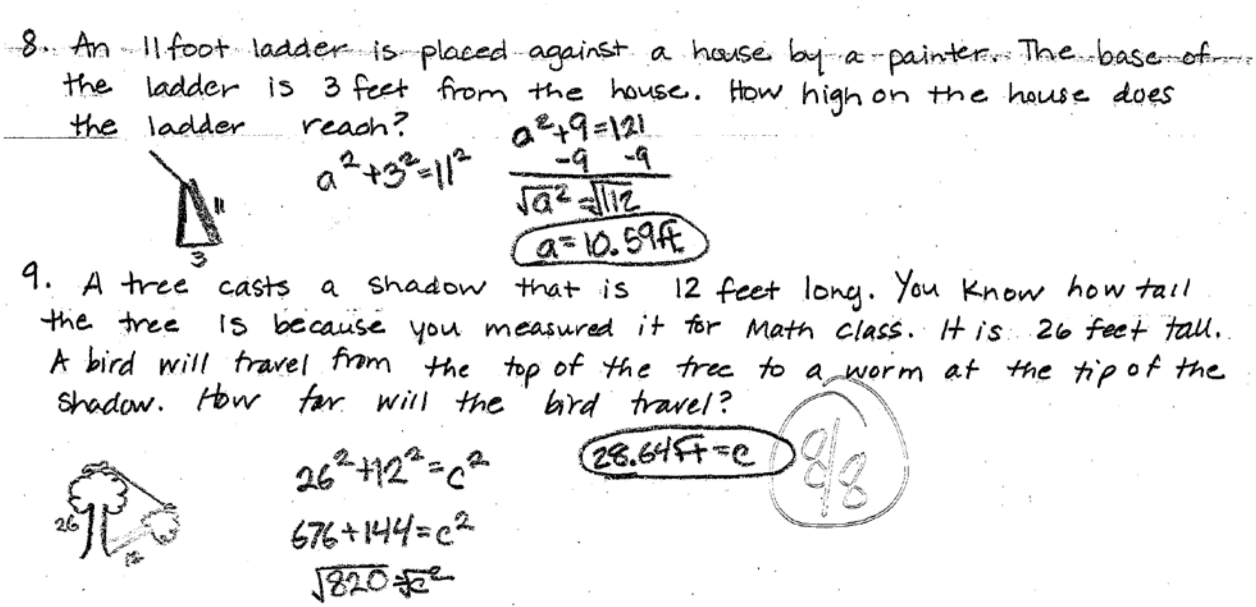
What happens to the level of student understanding after I implement greater manipulative use in the mathematics classroom? My findings suggest that students tend to understand mathematics concepts better when they draw pictures. The evidence that supports this claim is that several students have commented in their journals that drawing pictures is helpful to them. One student specifically states “drawing pictures makes it real and it was helpful because we could compare it with something . . . it showed you were more organized” (Student Journal, March 20, 2009). This sentiment seemed to be the consensus of the class.

The drawings also made students think more about what they were doing, as noted in my journal. I asked my students to create a mat using a protractor and ruler to draw as many different triangles they could using both ways to classify a triangle (angle and side). I wanted to see the various arrangements that could be made. In my journal I mention, “I heard students talking about how this triangle couldn’t work because of this reason and why they thought another peers wouldn’t work because of this that reason” (Personal Journal, March 20, 2009).

This dialogue is a result of student understanding of a concept or their process of working through to understanding.

Finally, the last piece of evidence that supports my claim of drawing increasing student understanding is attempts made by students on tests and daily work to draw pictures to help them organize information. One student on a test drew a picture of a tree and labeled its height and then drew out the shadow the tree created and labeled it as well as the house and ladder for another problem. Another student drew pictures to explain his reasoning to a bonus question instead of using a complete written expression.





This was exciting to see, not only because my students answered the questions correctly, but also I was able to see and understand their thought process as the students were solving the problems. I knew that they understood what the problem as asking for, and that each student knew how to solve the problem. Drawing the pictures made their work organized, which students noted earlier in their weekly journals. I chose this as an example of how drawing pictures can be beneficial for student understanding.

Students had fewer misconceptions when working with manipulatives relating to polynomials when manipulatives were used in instruction. When reading student journals this assertion may seem misleading. When asked “which method (representation or numerically) of solving these problems do you prefer,” only five said they prefer using representations, while 15 said they prefer to solve it numerically. But, when asked the question, “which method helped you understand the concept more” of those 15, five said that the representations helped them understand more because they could see how it worked. Of the remaining 10, the time the problem took to represent was a reason why they either preferred using numbers or they understood more with numbers.

Another example of understanding is found in my student interviews. Several of my students noted that they preferred using manipulatives because it allowed them to “visualize” the problem. One student even used putting an engine together as a metaphor for using manipulatives. He said, “if you are putting an engine together you can’t do it on the board, you have to do it in your hands” (Student Interview, March). Doing the problems with manipulatives allowed him to put it together himself.

Finally, when tested on the concept of adding and subtracting polynomials four students failed the numerical portion of the test, but scored 100% on the manipulative test. In addition to this, every student either scored a 100% on the manipulative test or only made the simple mistake of not adding the opposite integer when subtracting on the manipulative test. This is important to this study because I believe that it shows that manipulatives aid student understanding. When students are asked to solve problems using manipulatives they slow down. This helps students not make as many errors. The time issue was noted in my journal “kids would say that they UNDERSTOOD it better using manipulatives, BUT that they took too long” (Personal Journal, April 12, 2009). When students are using tools or drawing pictures, they are thinking about what is happening, further aiding understanding of the problem.

Obviously, there are mixed results here, but overall, what I see is students not knowing exactly what they need to be successful. I think that students are looking for the quick, easy way to get “it” done and do not want to take the extra step, even if it may benefit them. The quick and easy road does not always lead to the path of “understanding” math, just “doing” math. Just “doing” math does not necessarily mean mastery nor does it encourage long-term retention.

How do the attitudes of my students change when manipulatives are infused in the mathematics classroom? Attitudes about mathematics are directly related to student understanding and success. The evidence that I have to support this statement exists in three areas: the pre-intervention survey, student journals and a comparison of student journals to their grade earned on tests. In the survey I asked the students several questions. The first was “do you like math?” followed up with, “why or why not?” I then took it another step and asked them to reply to “do you feel like you are successful (regardless of your grade) in the mathematics classroom?” followed up with “what makes you feel successful?” From this information I tallied student responses to get an idea of what was happening. Of the students who responded to the question positively toward math, the number of students who felt their grades made them successful was double that of those who liked it because they understood it. As well, disliking math was related to both lack of understanding and grades.

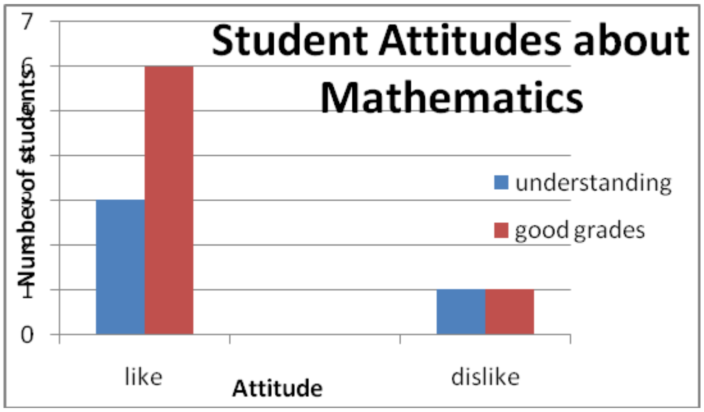


Figure 1- Pre Intervention Survey Results

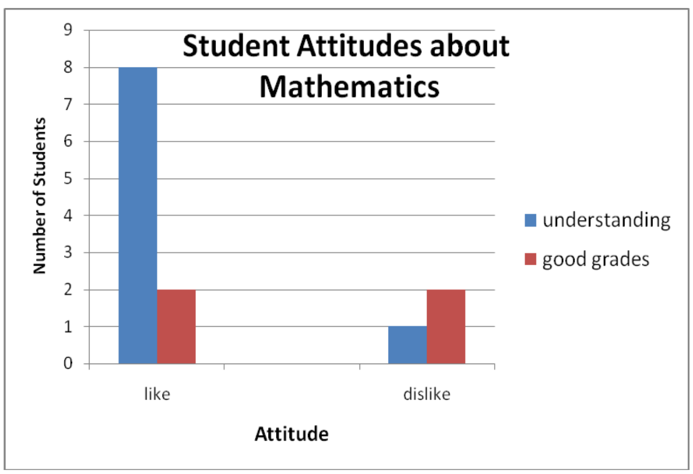


Figure 2 – Post Intervention Survey Results

The second chart shows the results from the post-intervention survey. Here, the infusion of manipulatives into my classroom has not changed the number of student who like math, but it has changed the students' rationale. They no longer are attributing liking math to getting good grades, they are attributing success to their understanding. This rationale change is fantastic!

Another reason I belive that student attitude is related to understanding is found in student journals. In these journals, students would refer to their understanding of the concepts if they liked the concept. For example, one student wrote, “I like using the pegboards, it helped me understand a lot better” (Student Journal, February 6, 2009). Another, “peg boards makes it funner and easier to learn” (Student Journal, February 6, 2009). These are representation of how the majority of my students responded. In general, if my students like the concept that we were working with, they tended to explain their reasoning was because they understood it.

More examples of liking/understanding phenomenon occurred with different concepts as well, not just the peg board graphing. One student said of watching computer-generated manipulation of Pythagorean Theroem, “the motions of the objects keep your attention on the screen so your [you’re] always paying attention” (Student Journal, March 12, 2009). Another student said that she enjoyed drawing the pictures of the triangles because “the activity helped me to get better at drawing angles” (Student Journal, March 20, 2009).

One of the first activities that we did with manipulatives was using pegboards when graphing equations. I compared student journals to their test on graphing. On the tests, I only looked at the problems students were asked to graph an equation. Every student was proficient, scoring at least a 10 out of 12 possible. The only points that were not earned on three students’ tests were that the students did not account for the negative slope; otherwise, they positioned the *y* intercept correctly and used the slope of the equation to graph the points. When I looked at the journals after scoring the tests, the majority of my students commented that using the peg boards was fun, or that they liked working with their peers. There were six students who commented that it helped their understanding, but only one of those followed that up with a reason: plotting was easier because it was bigger than paper. Students are equating understanding with having fun.

Here is another example where student journals played an integral role of examination of student attitude. I looked at the journals regarding the questions related to drawing triangles and compared it to their grade on the test over that concept. I reviewed the tests of the students who turned in a journal commenting that they liked the activity for one reason or another. I observed that of the 16 students who said they liked the activity, 12 were proficient (getting 10 or 11 out of 14 items correct) or advanced (13 or 14 out of 14) on the test, while two were progessing (8 or 9 out of 14) and two were beginning (less than 8). One student who scored a 7/14 on the section confused isoceles with scalene continually, bu this was the only error made throughout the section. There was one student who did not think the activity helped her and she scored an 11/14. Another student, who has an Individualized Education Plan for written expression, but is otherwise brilliant, does not turn in journals. I did not force the issue for the sake of my research, although I would love the insight that she has. She scored a 14/14. I believe that these results are showing that when students work with the concepts, using manipulatives, creating a drawing or recreating the concept in a manner that makes sense to them, it increases their understanding, which in turn increases their grade and attitude toward mathematics.

I believe that using manipulatives changes student attitudes to be more positive toward mathematics and makes them more successful. When given the pre-intervention and post-intervention surveys regarding student attitude four students said they did not like math before intervention, while the rest of my students said they liked math. In the post-intevention survey the number of students who did not like math dropped to three students. I believe that this is related to the increased time spent working with peers and doing hands on related projects in class. Two of the three students who said they did not like math in the post-intervention survey, both said that they disliked it because they did not see how it was relevant to them. These were also the two students who continually wrote in their journals that they did not like using manipulatives because the time that it took to use them. They wanted to just “do” math. It is possible that only working with manipulatives over a three-month span is not enough time to reverse the conceptions that nine years of “traditional” math lessons have embedded in these students’ minds.

Another reason that I believe the use of manipulatives makes students more successful and increases attitudes in mathematics is because of the social side of using them. When we use manipulatives, usually students have their own set, but I want the students to work in groups. I want them to talk it out and work together. In my student journals, over three-fourths of my students said they like doing the activities and group work. This is echoed in an interview with two students:

> MG: what is your favorite activity that we do?
> Sarah*: group work.
> MG: what about group work do you like?
> Sarah: helping each other and trying to figure out the answer.
> Elijah: yeah, comparing answers with our peers to see who is right and who is wrong, it helps us understand it more when our peers are talking to us.
> MG:what about your peers helps you?
> Sarah:Teachers don’t talk like us, in our language, and when our peers do it is easier to understand.
> MG: What is your least favorite activity that we do in class?
> Sarah: working in the book, it gets boring (Student Interview, April 2009).
> *all student names are pseudonyms

It is obvious that middle school students perfer to be actively involved in the lesson and enjoy being able to communicate with their peers. These two components to the daily lesson positively increase student attitude toward mathematics.

I also found evidence of students attitudes improving with daily participation in my teacher journal. I wrote that “students were fighting to come up to the projector to show me what they learned" (Personal Journal, April 1, 2009). I remember writing this and being excited for my students. They really understood the manipulatives and wanted to come up and show their work to the class. This eagerness and excitement implies a positive attitude toward the math content.

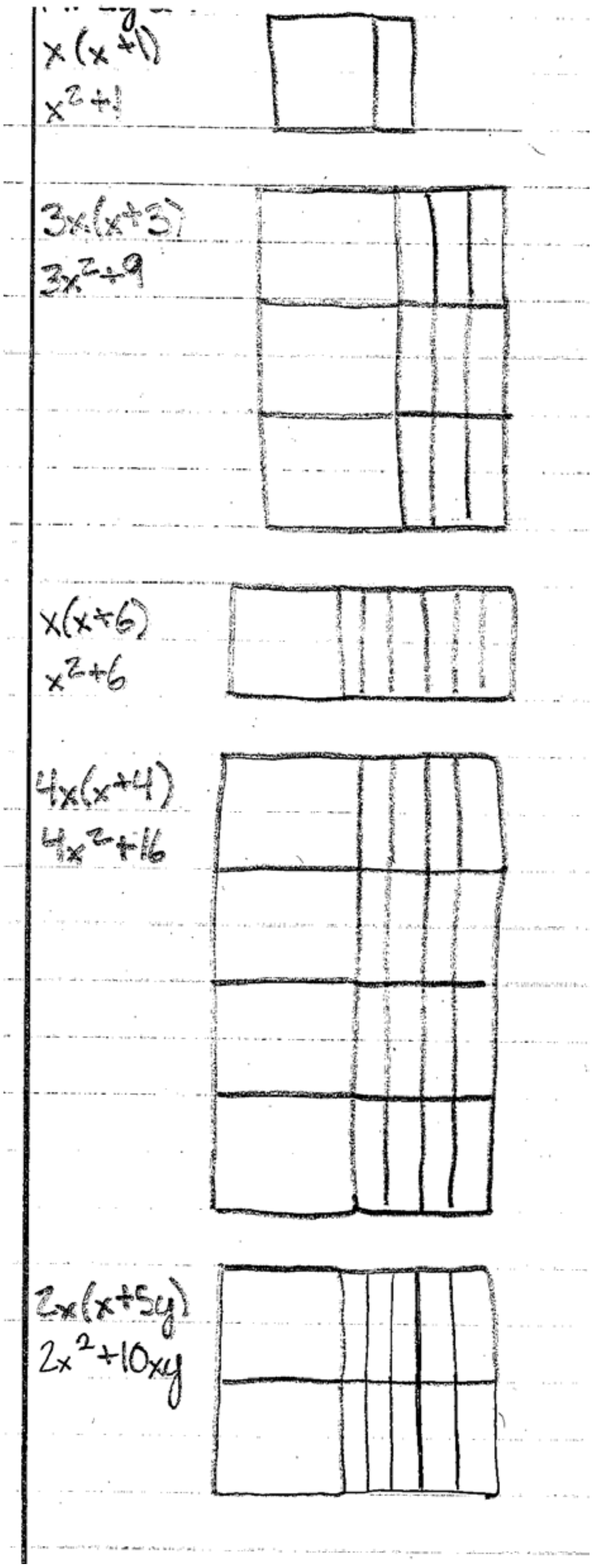
What does my teaching look like when I attempt to infuse more manipulative use into my classroom? By including manipulatives in my instrucion, I am getting the opportunity to see, hear and read first-hand how my students are learning. This is backed up by evidence from my teacher journals, from student journals and from student work. First, in my teacher journals, on March 19 I wrote that:

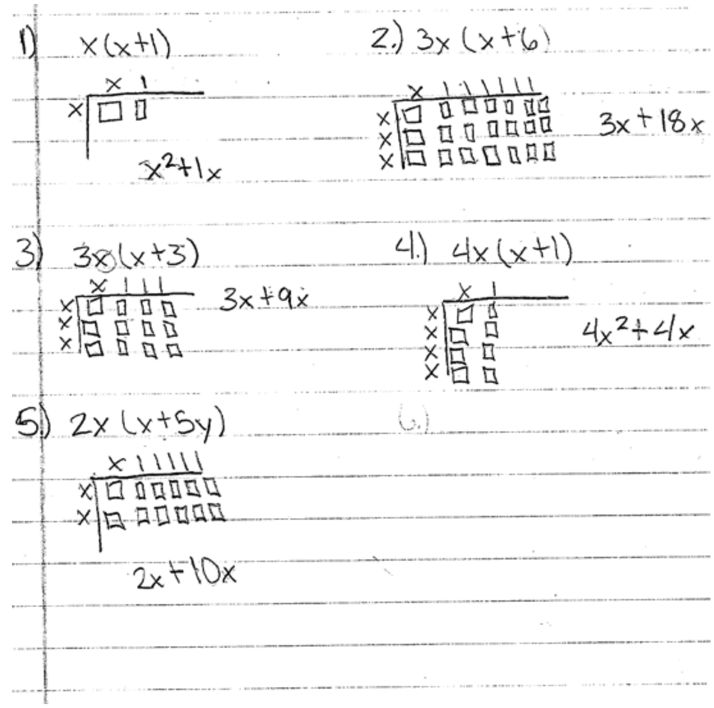
> I like being able to freely move around the room, giving me the opportunity to ask one-on-one questions and not be at the board. It give kids the opportunity to show me what they know by another means than homework. I feel more connected to the kids and I feel a better teacher because of it.

Another example of my journals telling this story is that:

> when I was drawing triangles, students were calling out answers. I would never have been able to monitor to make sure every student was understanding – only the loudest of the groups! This activity [creating a mat], allowed me to roam around the room giving each student attention, as I watched them draw, analyze and organize the information (Personal Journal, March 20, 2009).

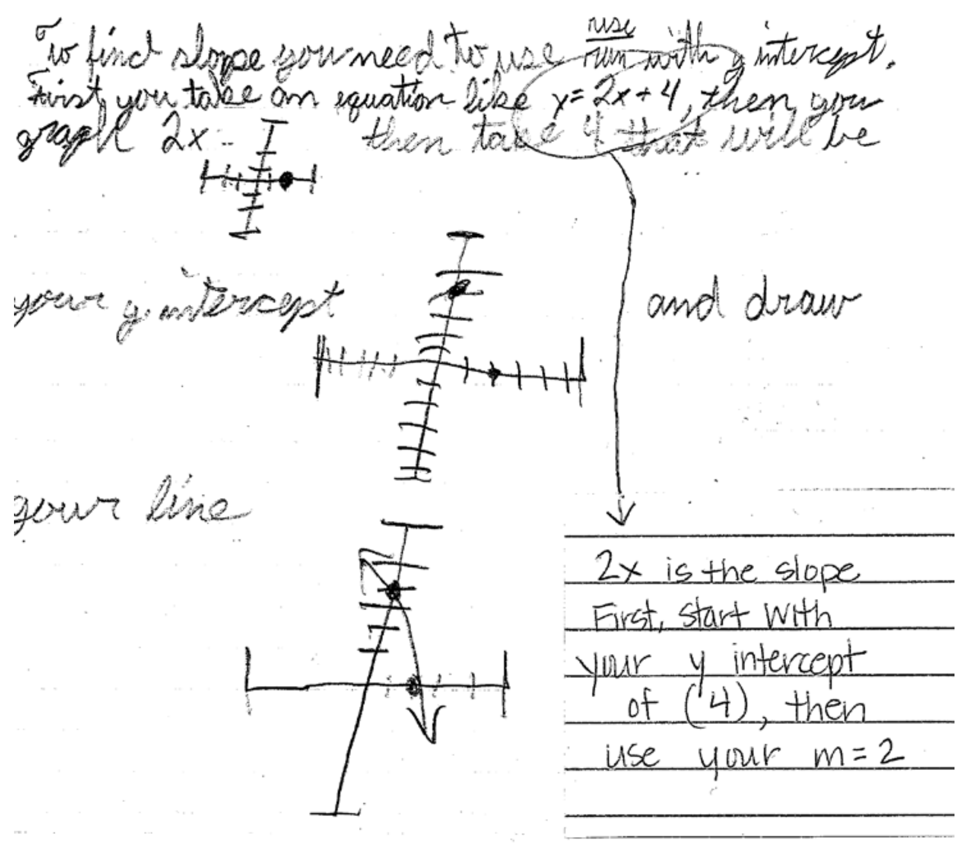
The students were asked to draw out pictoral images of their problems (as homework) or use the tiles in class as we were working problems. In the homework examples of my students, I am able to see what they were thinking and how the arrived at their answer. The first example of student work shows the student just drawing out the squares. Here I cannot ascertain whether the student truly understands what is happening when she multiplies, or if she is just going through the motions. All of her answers are completely correct but her representations are not. The second example shows the student's thought process of why the number is multiplied. She shows the *x* and *y* axis and what they mean in the multiplication process. Although she is not consistent in her answers, because only two of them have the *x* squared, her representations are all correct. I believe that the thought process is present, but mastery has not been obtained.





Asking the students to journal was an insight to me throughout the whole process. In each journal I learned something about most of my students. I learned from their writing if they did not like an activity or if they did not understand what I was trying to accomplish and even if the student was afraid to ask a question. This gave them the freedom to speak their minds without fear of what their peers may say. Without having journaled about different concepts including manipulations, I would not have been able to read what was going on inside the minds of each of my students.

For example, when we were graphing equations and using the peg boards, I asked my students to journal for me how they would go about graphing an equation. This example is taken from a student journal, February 2, 2009. This particular student never raises his hand and is often the source of ridicule; he would not have participated in class, nor would he have come to ask any questions. Because I asked them to explain in their words how to graph, I was able to catch his misconception and correct it, before the formal assessment was given.



Another assertion I have is that I believe that by using manipulatives, I have slowed down and have really been focused on student understanding, which has benefited my students. Half of my students wrote in their journals that they feel that I have encouraged them more this semester to find alternate ways to solve problems. “It also helped me by giving me more ways to solve problems” (Student Journal, April 3, 2009) was written by one student. Several of my students also noted that I have slowed down and made it more “funner.” One student wrote that “the more projects that [we did] helped us understand more” (Student Journal, April 3, 2009). Another wrote “I like how you helped us learn about something we didn’t get, or is hard for us to understand” (Student Journal, April 3, 2009).

I have written in my teacher journal, dated April 1 that …

> . . they have to think outside the box. They are looking at math in a different way, which is making them think differently. They do not like being asked to look at things from another perspective, especially if they “get it” another way.

This is an example of me pushing my students to look at alternate ways to solve problems. They want to get it and move on, instead of slowing down to look at the whole picture. This is also a good example of how I am focusing on student understanding. By using different approaches to teach, more student learning styles are being considered.

Finally, in my student interviews, one student said, “I like it [this semester] better because you are making it more understandable. It is like in our perspective then in the books perspective like you are making it so we understand it more and you are making it a lot funner because we are not doing the same things over” (Student Interview, April 2009). This statement is a dual meaning to me. First, I will address “doing the same things over.” Most of the fall semester is solving equations, such as: one step equations, two step equations, equations with fractions, with decimals, with variables on both sides, combining like terms, etc. This does get repetitive, however it is weaved through with other review concepts. Second, during the spring semester we did get to do different math concepts, and I moved away from the book more. I started drawing from other resources to get the concepts that I wanted to teach that were not complete enough for me in our text book. My students liked this. One student said in his interview with me when asked what could he change about my teaching, he replied, "probably like not much because you don't, like last semester you went straight through the book and this semester you are not going by exactly what the book says" (Student Interview, April 2009).

I conclude, based on these pieces of evidence, that the introduction of manipulatives into my classroom has changed my teaching positively. I am certain that my students know that I am focused on that, and they see and know it too. They obviously know that I care about them and want them to succeed. One student wrote in his journal, "you also want us to do better on our homework and to understand our lessons better" (Student Journal, April 15, 2009).

It is evident to me, that through the course of using manipulatives in my classroom, student attitudes about mathematics have increased and they are excited to come to math class. Student understanding has increased due to the use of manipulatives in content instruction and my teaching has changed to be more student-centered.

Conclusion

As a teacher I find that these results lead me to look for more ways to incorporate manipulatives into my lessons. Students on a whole enjoyed math class more or began to enjoy math more as a result of using manipulatives. Some of the enjoyment came from the socialization with their peers, while more importantly some enjoyment came from understanding.

My results for attitude mimic those of Sowell (1989) in which she found that concrete materials when used in extended learning structures was beneficial to student learning. It was also noted in her findings that “attitude measures were significant in favor of the concrete instructional condition” (p. 502).

Noble, Nemirovsky Wright, and Tierney (2001) found that students completed understanding through experiences not mathematical ideas. I would argue that by experiencing the manipulatives the students are building their own understanding as the subjects in the Noble, Nemirovsky Wright, and Tierney (2001) did with racing.

Moyer (2001) noted several times that teachers referred to “fun” as a means of measuring success of math class. In my journals I saw the word “fun” written many times. I think that I need to be careful when including manipulatives into my classroom that “fun” does not overshadow the concepts of mathematics that are being presented. I do not want my students to associate non-manipulative-instructed concepts as “real math” and manipulative-driven concepts as “fun math” as Moyer (2001) pointed out in her study.

Implications

The outcome of my study leads me to believe that the regular use of manipulatives will increase student understanding. As a result, greater understanding will increase confidence and attitude toward mathematics. What this means for me as a teacher is that I need to find ways to introduce manipulatives into instruction, either directly teaching or indirectly teaching. It is apparent that students not only gain valuable experiences from using the manipulatives, but also it allows them to create their own understandings and affords them the socialization that middle school students desire.

When the students used manipulatives they had fewer problems to solve. The reduction in problems allowed the students the time to really understand what was happening. I also believe that I will continue this practice in my teaching as students seemed to benefit, they no longer just want to “get it done.”

I intend on reaching out to my peers both in my school district and in my service area about the effects that manipulatives had in my classroom. It is my intention to create a presentation sharing my findings along with sample lessons that teachers can take and use in their classrooms. I believe that the more manipulatives are infused into daily instruction, the more students will see success and create their own understanding of the math concepts that they are engaging in.

Finally, my last idea to further this study in my teaching is that I plan to focus on student drawing to help organize thoughts. This strategy does not require concrete objects, making it more time efficient but still has the desired outcome. Students who are creative thinkers will benefit from an additional teaching strategy as well as those students who struggle. This practice will help them organize and compartmentalize information when solving math problems.

Reference

Clayden, E., Desforges, C., Mills, C., &Rawson, W. (1994). Authentic activity and learning. *British Journal of Educational Studies, 42*(2), 163-173.

Eastman, P., & Barnett, J. (1979). Further study of the use of manipulatives with perspective teachers. *Journal for Research in Mathematics Education,10*(3), 211-213.

Green, M., Flowers, C., & Piel, J. (2008). Reversing education majors' arithmetic misconceptions with short-term instruction using manipulatives. *Journal of Educational Research*, *101*(4), 234-232.

Kyriacou, C. (1992). Active learning in secondary school mathematics. *British Educational Research Journal*, *18*(3), 309-318.

Lappan, G. & Ferrini-Mundy, J. (1993). Knowing and doing mathematics: A new vision for middles grades students. *The Elementary School Journal*, *93*(5), 625-641.

Moyer, P. (2001). Are we having fun yet? How teachers use manipulatives to teach mathematics. *Educational Studies in Mathematics*, *47*(2), 175-197.

Meira, L. (1998). Making sense of instructional devices" the emergence of transparency in mathematical activity. *Journal for Research in Mathematics Education*, *29*(2), 121-142.

Outhred L. & Mitchelmore M. (2000). Young children's intuitive understanding of rectangular area measurement. *Journal for Research in Mathematics Education*, *31*(2), 144-167.

The National Council of Teachers of Mathematics, Inc. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

Sowell, E. (1989). Effects of manipulative material in mathematics instruction. *Journal for Research in Mathematics Education*, *20*(5), 498-505.

Appendix A

Pre- Intervention Survey

Name _________________ (optional)

1. How often do you use manipulatives (ruler, dice, drawings, counters, etc) on a weekly basis?
2. What do you see as the teachers purpose for using these tools?
3. Do you like using them? Yes No Depends? On what
4. When you use the manipulatives, do you know what you are “supposed” to be learning?
5. Do you like math? Why? Why Not?
6. Do you feel like you are successful (regardless of your grade) in the mathematics classroom?
7. What makes you feel successful? Or unsuccessful?
8. How often would you like to use manipulatives in class?
9. Do you ever use manipulatives while doing your homework? If so, explain how. If not why?
10. Can you think of a time, that your teacher used manipulatives with your class and you didn’t understand what she was showing you? If so, please explain.
11. Did you ever master the skill? If so, how, what did you or your teacher do to help you?
12. What has been the favorite thing that you do in math class?
13. What is the least favorite thing you do in math class?
14. Do you have any other comments you want to share?

Appendix B

Interview Questions regarding attitude

Why do you think we use manipulatives in class?

When using the tools, how do you know what you are “supposed” to learn from it?

When we use them, can you see the math ideas that I am trying to teach?

When do you feel more comfortable with concepts, with the tools or when we use numbers at the board? Explain why you feel that way?

Can you think of a concept that using the manipulatives was too abstract?

Interview Questions regarding what my classroom looks like

What is your favorite activity we do in class?

What is your least favorite activity we do in class?

Think about last semester in my classroom, what has changed, if anything?

Do you like it more or less? What about the change is desirable?

What, if anything could you change about my teaching? Why?

Appendix C

Volume of a cone hypothesis:

$V = \frac{1}{2} b \cdot h$ Joshua

$V = \frac{b \cdot h}{4}$ Emmy

Volume of a pyramid:

$\frac{2}{3} b h$ Kyle

Appendix D

Students solving equations using the pegboards

Students using geometric solids to find the volume of a cone and pyramid

Students using algebra tiles to represent adding/subtracting of polynomials

Students using chips to represent polynomials