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WHAT CAN BE DONE TO ENGAGE STUDENTS IN MATHEMATICS?

CAN MANIPULATIVES BE AN ANSWER?

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ABSTRACT

This action research report documents the observed and reported effects of teaching Algebra with manipulatives. The study was conducted in an urban high school in eastern Pennsylvania. The study involved nine Algebra I students using algebra tiles to learn how to perform integer operations, combine like terms, and solve one-step equations in a homogeneously grouped bottom track class.

Methods of data collection included assessments, surveys, questionnaires and observations kept within an ongoing field log. Methods of analysis included anaylzying data within the field log, finding common themes throughout the field log, and analyzing surveys, questionnaires and student work.

This study suggests that the use of manipulatives to teach algebraic topics increases student participation and motivation. While the use of algebra tiles can play an important role in an increase in student performance, manipulatives are not a panacea. Problems include time management, motivation, and previous phobias about mathematics. Eight of nine participants, however, reported they enjoyed the activities and felt that they helped them to learn the concepts taught.

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I would first like to thank my Applied Algebra I class. For without them, there would be no study. They were all very cooperative and willing and I am grateful to have had such a great class. I thank them for their patience in doing new activities within the class.

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RESEARCHER STANCE

It was the beginning of my senior year of high school, and I decided to take an additional course called Honors Math. I had no idea what we would be asked to do in this class or what I was going to learn. All that I knew was that I loved math and the teacher who was assigned to teach the class. So, instead of sitting through another boring study hall, why not give it a try? Honestly, by this time I knew that I was really good at math and I enjoyed doing math problems. However, I had no idea at this time just how much I was really going to enjoy this class above all others that I was taking or had taken.

Unfortunately, without going back and looking it up, I could not say what specific topic or concepts I learned about in this class. What I do remember are the hands-on activities we did and the incredible new math abilities that I gained as a result. This course was all about exploring math, so we looked at problems and problem solving from many different perspectives. Here we used puzzles and models and many hands-on activities. In the beginning it was just plain fun. I could not believe that I was getting a grade for playing with puzzles. However, as time progressed I realized that my classmates and I weren't only playing, but we were learning probably more than I ever could have imagined learning in any traditional class. Through the use of hands-on activities, I learned how to solve problems. I learned how to think rationally and how to use deductive reasoning despite the fact that I probably could not have given you that word at age 17. I

learned persistence and diligence and to this day, I am still determined to finish any task before me. I also still love the challenge of puzzles of any type, not just mathematical ones.

Math has always come easy for me. There is always a procedure to follow that will result in one definitive answer. However, through my years of teaching, I have come to realize that math does not come easy to everyone. Not every person thinks analytically. It is not easy for some to see the processes that lead up to the answer. Many students see a letter and ask, “Why are there letters in there? This is a math problem.” Today, I am the teacher and I do not have the luxury of teaching an elective class that is full of discovery, so I am also realistic. I know that the majority of my students dislike math and some of them downright hate it. This is especially true when it comes to my applied level students. Therefore, I want to try to bring some of that discovery learning to these students, who often tell me that, when it comes to math they hate it and do not want to do it. They believe that they are not good at math and are never going to be able to learn it. Since many students arrive in my class having failed in the past, they often shy away from participating and getting involved in the discussion. It is my hope that with the use of hands-on activities, or manipulatives, that students will become more interested in what they are learning and be able to acquire mathematical content knowledge in different ways. This is the first and from my vantage point the most significant reason for my study.

The second reason for my wanting to do this research is that I hope to strengthen the learning that is taking place. Too often students are just memorizing what they are told and reproducing it when they are tested. They do not truly understand what they are being taught. Through the use of discovery, I hope that students may retain information better. The benefits go beyond learning how to do mathematical calculations to learning how to use deductive reasoning and abstract thinking, important goals of Algebra instruction. My love of mathematics and hands-on learning lead me to this research study. I hope to pass on at least a small amount of interest in discovery learning to my students.

LITERATURE REVIEW

Introduction

This research report examines the effects of using manipulatives to teach mathematics. Various studies have suggested that using manipulatives to teach mathematics has a positive effect in participation, attitude, and in some instances achievement (Balka, 1983; Garrity, 1998; Hinzman, 1997; Steele, 1993). I will put forth the reasons that there is a need for change in the mathematics classroom and summarize what previous research has found about the use of manipulatives.

The Report Card

No Child Left Behind legislation holds all schools accountable for improving student achievement in mathematics. However, according to a 2007 report in *Educational Leadership*, there are discrepancies between the levels of proficiency on state standardized tests compared to what is considered proficient on the National Assessment of Educational Progress (Perkins-Gough, 2007,p.1). According to the 2005 report, only 6.9 percent of students scored proficient or above when testing algebra skills (National Center for Education Statistics, 2005). Furthermore, students graduating from high school are inadequately prepared to perform in areas of mathematics. One in three students entering college is required to take remedial math courses prior to enrolling in a College Algebra course (Greene, & Winters, 2005). Even with this alarming statistic, a survey conducted in Kansas and Missouri found that parents believe that their children

are learning enough mathematics in school. Only 25 percent of the parents interviewed thought that their children should be studying more mathematics (Davis, 2007, p.1).

Also, “in 2003, 3.5 million youth ages 16 to 25 did not have a high school diploma and were not enrolled in school” (Bridgeland, Dilulio, & Morison, 2006, p.1). According to the survey conducted, 47 percent of the students said their main reason for dropping out was because school was not interesting. They felt they were not motivated to work hard (p.4).

Student Participation in Mathematics

“Typically, the biggest hurdle for many teachers is motivating secondary students to want to learn and keeping them interested” (Wilburne & Peterson, 2007, p.209). Active participation is necessary in order to succeed in mathematics. Students need to be able to perform the processes being taught on their own. According to Davydov (2005) in order for a student to show a true understanding of the mathematical operations being taught, they must be able to reproduce and demonstrate the entire process to another person (p.225). A student should also be able to properly execute any task related to a specific set of rules. “Instructional strategies requiring students to be active are more engaging than those in which students are passive” (Weinstein, 2003, p.159).

Students Attitudes Toward Math

"I'm not good at math," is a familiar comment heard from students. Within society there is a prevalence of negative attitudes toward math (Fawcett, & Shannon-Smith, 2007, p.2). It is believed that students' negative attitudes toward mathematics will take much effort and time to change because they are so ingrained in students' heads (p. 3). "Attitudes create a self-perpetuating cycle, children with positive beliefs about math perform well, which makes them like math and feel good about themselves: students with negative beliefs fall farther behind, which reinforces their low expectations and sense of failure" (Kober, 1991, p. 5).

Improving Student Achievement in Mathematics

For teachers, there are three essential requirements to consider for students to succeed. The first is to make connections among mathematical topics for students. Students should see how ideas are related. The second is to build upon the students' prior knowledge. Students should be developing new understanding from their understanding of something they learned previously. Finally, students should be able to explain their correct answers. Just because students can get a final answer, if they cannot explain their reasoning, they do not truly have an understanding of what they have done (Burns, 2007, p.1-2). Students need to develop a true understanding of what they are learning. If students approach

mathematics as if it were just a process of memorizing rules, they will not retain the information (Lubienski, 2007, p.3).

Methods

It is suggested that in order for students to succeed in higher-level mathematics, they must first have a true understanding of basic mathematical operations, including addition, subtraction, multiplication and division of single digit numbers. This means they understand the meaning of the operations rather than just memorizing the answers (Lubienski, p.3). Since the majority of students are not proficient in algebra by the time they leave high school (recall only 6.9 percent scored proficient or above), there is a need for algebra to be taught across the grades (Ketterlin-Geller, Jungjohann, Chard, & Baker, 2007, p.1).

Instructional Differentiation

Extensive research conducted by Tomlinson (1998) confirms the need for teachers to provide differentiated instruction. All children are different and because of that they often learn differently. She stresses the fact that most teachers "enter a classroom with a single lesson that they deliver to learners at a single pace and through a single instructional approach. But for many of our students, it will not be good enough" (p. 53). It is for this reason that the use of manipulatives must be considered to improve learning in mathematics.

Manipulatives

Definition

Manipulatives are defined as physical objects that are used to represent mathematical concepts. “They have both visual and tactile appeal and can be manipulated by learners through hands-on experiences” (Moyer, 2001, p. 176). Gardner (1993) stated in his book on multiple intelligences “a solution to a problem can be constructed *before* it is articulated” (p. 20).

Manipulatives are used to enhance the learning of students through the use of hands-on activities. Students are better able to visualize concepts when they utilize manipulatives (DeGeorge, & Santoro, 2004). By using manipulatives, students are able to create alternate experiences for learning. According to DeGeorge and Santoro

> Hands-on educational experiences move students beyond the traditional and passive practices of teaching and learning by incorporating creation, expression, and the presentation of ideas. Spectacular results can be achieved when learning is taken off the chalkboard and literally put into the hands of the learners themselves. (p. 28)

Greater Student Engagement and Achievement

It has been found that teaching with manipulatives benefits a child with math learning disabilities (Balka, 1983). However, manipulatives have become

more than just an intervention for special education. According to the National Council of Teachers of Mathematics, there is evidence showing that manipulatives are beneficial for all students (Berkas, & Pattison, 2007, p.1). “A curriculum with goals for students of valuing mathematics, being confident in their abilities, making mathematical connections, becoming mathematical problem solvers, and learning to reason and communicate mathematically is a call for classrooms in which students are actively involved in learning” (Joyner, 1990, p. 6). According to Kober (1991), studies have shown that teaching math with manipulatives has a positive effect on mathematical achievement as well as improving student attitude (p. 19). Motivation can be created by the use of manipulatives. A research study conducted by Steele (1993) found that when students worked with manipulatives they were more likely to show an “internal motivation to do well” (p. 19).

After conducting research on the effects of teaching geometry with manipulatives, Cindy Garrity (1998) concluded that

> The increased level of enjoyment by the students, the positive reinforcements created by this type of teaching, and the lack of boredom, both for teacher and student, caused by the variety of teaching methods, make the extra efforts (of using and creating manipulatives) worth it.” (p. 39)

Her study was conducted in two tenth grade geometry classrooms. She found that students were frustrated by the inability to visualize and understand geometry problems. She began her study with a survey and found that 55% of the students disliked math. She conducted her study using one class as a control group, in which chapter one was taught in the traditional lecture method. Chapter one consisted of the core topics and definitions necessary for geometry. The second class was the experimental class. She began teaching this class starting with chapter one with the use of manipulatives and cooperative learning. After the first chapter, both classes were taught with the use of manipulatives and cooperative learning. She compared test and quiz scores between the two groups and each time found that the experimental group had a higher average score than the control group.

Other favorable outcomes were found through similar studies on the use of manipulatives in a math class. Through a survey conducted in her classroom, Kristina Hinzman (1997) found “students felt more comfortable with math and found more success” due to the use of manipulatives in class (p. 52). She also reported “the overall feelings of the students and their attitude toward mathematics did improve” (p. 54). It was also concluded by Don Balka (1983) that the use of manipulatives improved computational skills with slow learners as well as motivated them to participate in class discussions (p. 8).

Using Manipulatives Correctly

Many suggestions have been given for using manipulatives successfully. Some guidelines given by Joyner (1990) include: 1.) Give students time to explore on their own, 2.) Make distribution and clean-up as smooth as possible by preparing materials ahead of time, 3.) Establish clear expectations of students as well as clear guidelines, and finally 4.) The teacher should model the use of the manipulatives.

Teachers can help students to transition from arithmetic to algebra by first allowing students to use concrete objects to represent concepts that are being taught. Once the student can represent the problem with manipulatives, there should be clear verbal instruction. The students should be taught in a step-by-step fashion. Finally, students should be able to verbalize what they have learned (Ketterlin-Geller, et al., p.3). “Other areas of research on the use of manipulatives show generally positive impacts when manipulatives are combined with (1) virtual manipulatives software, (2) reflective practices, (3) cooperative learning, or (4) learning activities that are exploratory and deductive in their approach” (Berkas, & Pattison, p.1).

Problems to Avoid

Moyer (2001) conducted a study to examine how teachers use manipulatives to teach. She found that most teachers were unsuccessful in

connecting the manipulative activities with the content knowledge. More often manipulatives were used to reinforce previous knowledge or because they were fun.

A study conducted by McClung (1998), looked at the effect on student achievement when using manipulatives in a high school Algebra I class. The study compared two groups of students. One group was taught in the traditional manner and the other was taught with the use of manipulatives. The study found that the students who were taught in the traditional manner actually achieved a higher mean test score on a posttest. They concluded that the use of manipulatives could actually be detrimental to student achievement. One of the reasons that this may have occurred is that the students were using manipulatives to learn; however they were not allowed to use them on the posttest (p. 43).

Much of the failure associated with learning algebra is related to a lack of participation and motivation. If used correctly, manipulatives can increase student participation and motivation. When students are actively involved in learning mathematics, they are more likely to succeed.

PILOT STUDY

Throughout the process of getting my master's degree, I have been required to do some mini-studies within my classroom to learn more about my teaching and to prepare for this endeavor. In the spring of 2006 I performed a pilot study teaching with manipulatives in my Applied Pre Algebra class. The success of that study encouraged me to stick with the idea and therefore come up with my question for this study.

I used to teach in a school that operated on a block schedule. Therefore I had to keep 30 applied level students meaningfully occupied for 90 minutes everyday. I used to use a lot of hands-on activities to try to reinforce the topics that I was teaching. Once I started teaching in a traditional nine period class with only 42 minutes per class, I diverted from those practices, so when I was required to come up with an action research idea to implement in my classroom, it seemed inevitable that I choose to do something with hands-on manipulatives. The reason I was no longer using manipulatives was I thought that within a shorter class period, there would not be enough time to cover the content and include the use of manipulatives like I had done in a block scheduled classroom. However, I do believe that adding the use of manipulatives can improve student engagement and achievement. By using manipulatives the students will have the opportunity to discover on their own and this will allow them to reinforce the topics that are taught.

This pilot study lasted approximately three weeks. Within that time I was teaching plotting points on the x and y-coordinate system. To begin the unit, I brought in miniature Battle Ship games for the entire class. I modified the game so that rather than using letters on one of the axes, I put the numbers one through ten to reflect the axes on a coordinate plane. Before I ever talked about plotting points, I allowed students to play the game of Battle Ship. At the time, the students did not realize that they were actually plotting points in order to play this game. After playing the game for two class periods, I taught them how to plot points on the coordinate plane referencing back to the game that they had played. Since the game only uses what would be considered the first quadrant on a coordinate plane, I had the students create their own Battle Ship board on graph paper. I required them to include something in each of the four quadrants. Then the students played again using the boards that they had created on their own. This was a great reinforcement for the students. They had to write down all of the points where they had placed ships on their boards and they had to write down all of the coordinates they chose while they were playing. When they were done playing, they had to compare points with their partners and they checked each other by doing this.

Overall, the study had a successful outcome. However, the biggest success from this study was one that I had not anticipated. I had two students in this class who truly despised each other. Since I chose the students randomly to work

together, these two students ended up being paired together. I was very worried about this initially because of the history between the two of them. However, they ended up working together successfully and were able to discuss their discrepancies rationally, helping me to see the value of social learning even in the mathematics classroom.

METHODOLOGY

Setting

This study was conducted in an urban high school of approximately 3000 students in the northeastern United States. The student population is approximately 65% white, 19% black and 13% Hispanic.

The study was conducted entirely within my classroom, containing 28 student desks placed in three rows of paired desks. There are two white boards, one in the front of the classroom and one in the back. There is a teacher desk on the side of the room and an interactive white board at the front of the room. There is a class set of laptop computers that can be brought into the room at any time for student use.

Participants

The study was conducted in a below-level tenth grade-level Algebra I class. The class consisted of eleven students. Of those students, three were male and eight were female. There were three ninth graders, seven tenth graders, and one twelfth grader. Two of the ninth graders are repeat ninth grade students. There were two students with Individualized Educational Plans (IEP). Each of the students with an IEP had a learning disability. These students were able to receive additional time for testing and alternative testing sites. They were also able to use a calculator at all times if they so desired.

Procedures

Before I began my study, I submitted a request for approval from my building principal (see Appendix A). Once I secured his signature of approval, I submitted an application with the Human Subjects Internal Review Board. With approval from the HSIRB (see Appendix B) I was ready to involve my students.

During the first week of class, I handed out parent consent forms to students (see Appendix C). I had the students take them home and have their parents read and sign them and return them to me. I also administered a generalized survey to determine the students' attitudes toward math (see Appendix D). I administered this same survey at the end of the study.

Throughout the study, I followed the same basic process for teaching each unit. I began each topic with one or two days working strictly with manipulatives. I then proceeded with traditional lessons referring to the manipulative activities in order to bring together new concepts. The manipulatives were available to the students at all times, even on days when they were not necessarily needed for a particular lesson. Students had the option of using the manipulatives on tests and quizzes if they chose to do so. Each unit was made up of several topics and took approximately one and a half to two weeks to complete. At the end of each unit, a test or quiz was administered that covered all topics that were taught.

The most common manipulatives that I used throughout this study were algebra tiles, or specific pieces cut to represent the variable x, x^2, and a unit or

constant (see Appendix E). There are different colors to represent positive and negative numbers. I created my own sets of algebra tiles out of card stock for each student. The students used these for most of the lessons and they learned how each lesson built upon the previous lesson and how the algebra tiles could be used to represent a variety of mathematical concepts that build upon each other. They started with simple mathematical computations and progressed to solving more complex algebraic equations. For other lessons, I sometimes used a variation of algebra tiles or I used completely different forms of manipulatives.

Data Sources

I used a variety of data sources. In order to achieve triangulation, I used four main methods of collecting data. The three methods were: 1.) The use of surveys and questionnaires, 2.) Questioning and student interviews, 3.) Observations recorded through a field log, and 4.) Assessment of student work.

Surveys and Questionnaires

The first data that I gathered was through a student survey that I handed out to all of the participants at the start of the study. The purpose of the survey was to get an idea of the students' perception of math and if they enjoy doing hands-on activities and group work. I distributed this same survey at the end of the study to see if the responses had changed.

As the study was underway, I distributed another questionnaire to each student. The purpose of this questionnaire was to determine why students have

such a frustration when it comes to math class. It also helped me get an idea of the students' perceptions of their math abilities. "A survey or questionnaire gives you a broad base for understanding your students' ideas in regard to your research question" (MacLean, & Mohr, 1999, p.41).

Questioning and Student Interviews

I often questioned the students about the methods and processes that we were following. Following the suggestions of Eder and Finderson (2002) at times, I would do whole group interviews to determine if the students felt that the manipulatives were helping them. Following a test, I conducted a whole group interview to determine if the students had used the manipulatives or thought about the process of using them while they were testing.

Observations and Field Logs

I kept a field log containing direct observations in conjunction with personal reflection for each day as suggested by Holly, Arhar, and Kasten (2005). Each day I observed the students as they worked with manipulatives and wrote down brief notes of what happened at the end of the period. At the end of the day, I recounted what happened during the class as an entry in my field log. I tried to ensure that any personal opinion or personal reflection was noted in the field log by enclosing it in brackets. Bogden and Biklen (2002) recommend that observer comment be labeled in this way when keeping a field log.

Assessment of Student Work

Finally, I analyzed student work as recommended by Holly et al. (2005). I kept note of when students were using manipulatives while testing and quizzing. I also analyzed those assessments to see how the students were progressing. At one point in my study, I re-tested the students using the same test that they had already taken but re-taught the lessons using manipulatives. Analyzing student work allowed me to monitor both their progress and their understanding. MacLean and Mohr suggest “student work may be the centerpiece of you data, helping you to understand and interpret all the rest” (p.47).

TRUSTWORTHINESS STATEMENT

In order to be ethical in the research that I have conducted, there are several steps that I have followed. I began the process by sending home consent forms for parents to sign allowing their child to participate in the study. Within the consent forms, it was clearly stated that participation was voluntary. If a student, parent, or guardian decided that they did not want to participate in the study, they were not required to and they were not penalized in any way. Also, if students initially chose to participate and then changed their minds, they could withdraw from the study by simply writing me a note. I made it very clear to the students that participation or nonparticipation in the study did not change what was being done in the classroom. All students were expected to engage fully in all classroom activities whether or not they were research participants. The only difference was that student data was not reported for students who did not wish to be study participants.

Once I received the signed consent forms, I began to observe the students. While students were working with manipulatives, I observed them to evaluate how they followed directions, their level of participation, were they on-task, and how they worked with others. I kept a field log containing direct observations in conjunction with personal reflection for each day as suggested by Holly, Arhar, and Kasten (2005).

I ensured confidentiality by assigning pseudonyms for each student. I also kept all documents pertaining to the research in a locked cabinet in my classroom whenever they were not in use. I made it clear to the students that what they were telling me was private and would only be shared with their identities concealed within the report unless it affected their health or well being. I kept the students informed as to what I was doing as well as the progress of the research. I periodically asked for their opinion about the program and their suggestions for improvement.

Going into this study, I had some biases about what may or may not happen. Of course, it was my hope that every student would enjoy every activity and learn from it. Realistically, I knew that this was not going to happen 100% of the time. I needed to realize that every student was not going to fully cooperate. Just because I was excited about the activities did not mean that every student would be as excited as I may have been. I hoped that the outcome would be students who participated more and were more involved in class and therefore, there would be improvement in learning. However, I knew that this might not be the outcome for all students. It was my hope that students would use the manipulatives even when they were not directed to do so, in order to facilitate what they were doing. I realized that I needed to be open to change and I realized that everything might not go as I initially had planned. Fortunately, I had a teacher inquiry support group that was able to help me to determine changes to make as

the study proceeded. They also helped me to try to look past my own biases and accurately evaluate the data that I collected.

OUR STORY

I am fortunate in the fact that I can say with no uncertainty that I love my job. Although at times it has its challenges and frustrations, I am fortunate to have a very rewarding career. I have been teaching so-called low-level students since I began teaching, and honestly, I enjoy that more than teaching students identified as higher-level. Perhaps the most rewarding thing as a teacher is having a student who insists that he hates math and could never possibly pass end up enjoying math and truly trying to succeed. If just one of my student experiences this a year, I know I have made a difference. It is for this reason that I have chosen my study. I believe that when students become interested and motivated, they can and will succeed.

Introducing the Study

I began my study the second week of school. I had already received consent from the Human Subjects Review Board as well as consent from my building principal. I had chosen to perform my study within one of my three applied level algebra classes. Although I knew that this would likely prove to be a challenge because of their lack of intrinsic motivation, I also knew that they could potentially benefit most from the study. I chose to use my second period class, which consisted of 12 students of varying levels of prior achievement in mathematics. I chose this group because of their uniqueness. This class contained all students who were taking the course for the first time. Some of them were

classified freshman but most were sophomores. One student was a senior taking a 10th grade course. I spent the first week getting to know my students.

With the exception of the one senior, the students that were in the class were on track, however the track that they were following was below level. The tenth grade students were Betty, Elli, Sara, Nicole, George and Allison. Betty was not very strong in math and she was always quick to let me know when she did not understand something. Ellis got average grades within the class but felt that she was placed in the wrong level. She thought that she should be in a higher level. I am not sure that is the case. Sara was very quiet and struggled a great deal. She had difficulty with basic math skills. Nicole was one of my strongest students. She always did well and always participated in class discussions. She had an Individualized Education Plan (IEP) but never wanted to utilize these accommodations in my class. George also has an IEP and he was another strong math student within the class. Both Nicole and George could move to a higher-level course. Allison was another quiet student who struggled at times.

The ninth grade students were Sherry and Christy, both repeat ninth graders. They did not receive enough credit last year to advance to the tenth grade class; however they did pass their pre algebra class. Sherry was very outspoken and always asked questions when she did not understand something. She often struggled with basic concepts but always put forth an effort. Christy was very

quiet and never asked questions. She struggled a great deal in the class. She also missed many days and this contributed to her lack of understanding many times.

Finally, there was Erica, the lone senior in the class. She transferred to the school the previous year with only a general math credit. She struggled to understand basic concepts in the beginning of the year but started to excel after the first marking period.

Once I had chosen the class for the study, I spent some time explaining to the students what was going to happen, noting that I, too, was actually a student and in order for me to improve my teaching I would be performing a study within their class. I explained to them that we would be learning some of the topics using hands-on activities or "manipulatives." I explained to them that volunteers would have to take a consent form home and have their parent or guardian sign it and return it to me. I received eleven of the consent forms back from the students out of the twelve that were distributed. I stressed to them that whether they chose to participate or not, they would still be doing the same thing in class. In the end, nine students opted to be active study participants. Although I received eleven consent forms, two students left my class, and one student never returned the consent form.

First Manipulative Activity

We were ready to try our first manipulative activity on integers. I handed out decks of cards, and the first task was to have the students put 10 cards in order

on their desk. However, they had to treat the black cards as positive and the red cards as negative. Elli's partner helped her by explaining that all of the red cards needed to be placed together and all of the black cards together. Sara assisted Betty by moving some of her cards into different spots. While the students were organizing their respective cards, George asked if the cards should be mixed or separate. I noticed that his were separate and the person next to him had them mixed. I was sure that this was the reason he asked the question. I responded with "I don't know, let's think about that. Should they be separate or mixed? What do you think?" By this time everyone had had an opportunity to perform the task, so we talked about what they should look like.

Teacher: Let's answer George's question. Should the cards be mixed or separate?

Students: [overlapping] Separate. They should be separate. Separate.

Teacher: Why?

Sara: Because some are positive and some are negative.

Teacher: And what does that mean?

Sara: The positives have to be on one side and the negatives on the other.

Teacher: So, where should the black ones be and where should the red ones be?

Sara: The black on the right and the red on the left.

Sherry: Like if you were doing one of those! (Pointing to the number line on the board behind me.)

Teacher: What card should be closest to the joker?

Sara: The Ace (one)

Teacher: What about on the other side, should the king be furthest to the right?

Sara: No, the one, the king is the farthest away because negatives are backwards.

Following this important conversation, I asked students to form pairs to play integer war, a game that I created to help students learn to compare integers. I explained how the game of "I Declare War" was played and told them we were playing that game with a twist. The students had to use black cards for positive numbers and red cards for negative numbers, the joker representing a zero and the ace representing a one. Once everyone understood the rules of the game, I let them begin, and I observed each group by circulating around the room as they played.

Some of the students really seemed to enjoy the activity; others seemed merely to go through the motions. I quickly visited each group to make sure they understood the concept. Then I circulated again, spending a little more time with each group watching what each student was doing. Nicole was the first student who noted aloud that a positive always beats a negative. I asked her how she

knew so quickly that she had won and she responded, "I win because mine is positive and hers is negative." She had realized something important that seems intuitive but often stymies students at this point in the semester: a positive number is always larger than a negative number.

Students had the opportunity to play for about 20 minutes, and then I had them put the cards away so that they could explain the point of the activity. Sara pointed to the board and said, "So we could learn that." There was a number line on the board with some inequalities comparing two integers. Immediately I asked what they had learned from playing the game. Elli explained that if she had a black card and her partner had a red card, she won because a positive always beats a negative. I was so happy to see that she had made this important connection. Finally, I asked what happened when both of the cards were red. Sara responded immediately, saying that the smaller one would win. I asked why that is true, and she told me, "Because negatives are backwards!"

While her response did not yet utilize the correct mathematical terminology, I was still very happy with the results of this day. The students were able to explain key new mathematical concepts in their own words. They now understood that positive numbers are always greater in value than negative numbers, and they understood how to compare integers.

After the students learned the rules for adding integers, I had them play integer war again. This time they each had to flip two cards and find their sum.

Whoever had the largest sum won the round. Students seemed to play this more intently than they had played the previous day. They were all looking at the board to see what each card represented and then calculating their sum. Requiring them to perform the addition of integers was a little harder, and they had to pay closer attention than when they were simply comparing single cards.

When they were done, I tried to wrap things up, asking them what they thought about the new version of the game. They said that because it was harder and it took longer, they liked the other one better. I was curious and asked what made the new version harder for them. They concluded that it was harder when there was a red and a black card. They had to find each sum and then compare but when adding integers of different signs together, one actually has to subtract their values to find their sum. This is sometimes quite confusing for many students to understand.

Pre-Study Survey

After their first lesson with manipulatives I gave my students a survey to fill out (see Appendix D). Some students didn't seem to like the format, however, because they had to choose *yes* or *no*, and they felt that one distinct answer was not always clear. As a result, I told them that they could write any added comments that they felt they needed to add. Many of them did at least answer *sometimes* or *maybe* for some of the questions. This actually made me happy

because this was telling me that they were actually reading, thinking, and not just circling any answer. The results of the survey follow.

Table 1. Results of pre-study survey.

	Question	Responses	
1.	I like math.	Yes – 5	No - 4
2.	I think math is hard to understand.	Yes - 2	No - 7
3.	I feel that math is useful.	Yes - 9	No - 0
4.	I feel that algebra will be useful.	Yes - 7	No - 2
5.	I think that this class will be hard for me.	Yes - 1	No – 7 (1 maybe)
6.	I like to do hands-on work.	Yes - 6	No - 3
7.	I like to work with partners.	Yes - 7	No – 1 (1 sometimes)
8.	I get good grades in math.	Yes - 7	No - 2
9.	What grade did you get in your previous math class?	Average grade = 82%	
10.	What grade do you expect to get in this class?	Average grade = 91%	

The number of positive responses to the survey surprised me. Although these students were in an applied level class, they felt that they did well in math.

The average grade expected at the end of the class was a 92%. I was excited to see that six of the nine participants indicated that they like to do hands-on work.

To confirm student conceptual understanding, I distributed a worksheet on evaluating expressions with integers and instructed students to work on this independently for about 20 minutes before comparing their answers and discussing any discrepancies with their partner. I was very impressed by this process as the students discussed their problems, explaining their methods to one another. Here I had not been sure if they would just copy each other's answers or actually discuss the problems, so I was especially pleased that the students were actually explaining clearly to each other how they came up with their answers. Although this day did not involve any manipulative activities, it did involve cooperative learning and it did show me that students understood how to perform mathematical operations, such as adding, subtracting, multiplying and dividing with integers.

For the next two class periods, the students explored order of operations on the classroom laptop computers. Students worked quietly and diligently on problems involving integer operations, but in retrospect I wish I had designed the activity to support student interaction.

Big Mistake

When I administered the traditional end-of-unit test on integer operations, I did not give the students the opportunity to use any form of manipulatives to

support their work on the test. I also did not review with any type of manipulatives but rather did a traditional paper and pencil review with the types of problems that would be included on the test. I realized that this was not an ideal situation. Several weeks had passed between the time students first used the manipulatives and the time they took the test.

The average grade on the test was a 67.6%. Although this is passing, it is in the D range and I believed that the students could have done better. There were no A's and Christy, Sara and Sherry failed the test. I realized at this point that I had planned on using algebra tiles when I taught this lesson. I had forgotten about the activities because it had been such a long time since I had created them. Once I saw the test results, I knew that I needed to do something else to help the students learn integer operations. I looked back at the plans that I had created the previous semester and found the algebra tile ideas. I thought that using the algebra tiles could have made a difference in the students' grades so I decided to try to teach integer rules again, this time using the algebra tiles.

To remedy this missed opportunity, I decided that the next few days were going to be dedicated to reinforcing integer rules instead of moving right into combining like terms. I realized that I would be doing these students a grave injustice if I were to ignore the fact that they had not mastered integer operations and simply move on with the next topic. My colleagues with the mathematics department and I had decided that these skills were important for students to

know and be able to do in preparation for the Pennsylvania System of Schools Assessment test. As a result, I introduced algebra tiles for the first time.

Algebra Tiles

I returned the tests and asked the class if anyone had thought about the card activities that we had done while they were taking their test. None of them had. I asked if they would have used the playing cards had I provided them. The consensus of the class was that they did not think about the cards and most likely would not have used them if they had been provided.

I explained to them that we were going to try something different to help them to build a better understanding of performing operations with integers. I introduced the algebra tiles and explained that we were going to work with these new manipulatives for a couple of days and then take the test to see if they could do better.

What are algebra tiles? Algebra tiles are rectangular shaped pieces representing a unit one, x and x^2. Each different value has a different shape and color for the tile (see Appendix E). Algebra tiles are used to help students represent algebraic expressions and see how they can be manipulated. When there is a positive and negative tile of the same type together, they cancel each other, so they can be taken away (see Appendix F). I created my own sets of algebra tiles out of different colored card stock. This allowed me to have a greater number of each type of tile to use for larger problems.

I started by having them using the algebra tiles only for adding integers. I told them that if they felt that they could do the computations without using the new tiles, they must still use the tiles to check their work. Once I felt that they understood how to add integers using the tiles, I introduced subtraction, giving them six new problems without telling them how they should proceed; I wanted them to come up with a method on their own. Nicole was the first student to figure out what to do, and I asked her to go up to the board and show the other students what she did. At the board, she showed them how she rewrote each as an addition problem and then used the tiles to do what she had done previously with the addition. Then she used my overhead tiles to show them the addition. When she was done, I showed them other methods for subtracting using the tiles. For example, I pointed out that they could represent the first number and then literally take away the number of tiles that were being subtracted, or they could think of each operation as a sign. I told them that they could pick the method that they preferred. However, I tried to encourage them to look at each of the operations as signs rather than plus or minus because this is the most valuable concept students can learn about integers. Subtraction is the same as adding a negative. There were so many times that I said, “minus is the same as a negative, a negative is the same as minus” that the students were sick of hearing it.

As I watched students work, I sensed that they truly had a better understanding of what they were doing. I was very happy with the participation

level as I noted every student using the tiles. Unfortunately, not every student was enthusiastic about doing so.

Over the next three days, the students reviewed adding and subtracting integers and then learned how to multiply and divide integers using the algebra tiles. I stressed that I wanted all of the students to use the tiles even if they felt that they did not need them. Unfortunately, just because I asked them to do so does not mean that all did. Some of the students used the tiles for every problem. However, some of the students in the class who had been performing well opted not use them often or at all.

Still, I think that as a result of using the tiles, most students had developed a better grasp of adding and subtracting integers. At the very least, I think use of the tiles helped them to understand that a minus sign is the same as a negative sign, a concept that many students have difficulty grasping. Many of the students who did not perform well on the original unit test performed quite well on the assignment. Kelly, who had barely passed the unit test, got every problem correct using algebra tiles. I asked her if she thought that the algebra tiles would have helped her on her test and she replied that she was sure they would have.

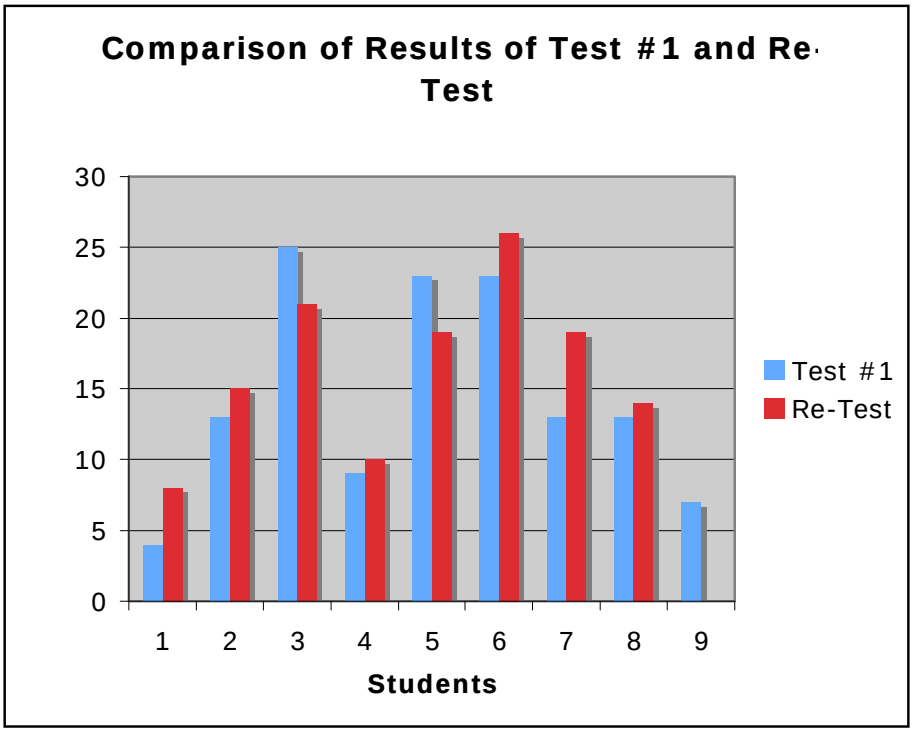
Re-Test

After spending four days reinforcing integer operations using the algebra tiles, I re-administered the same test that students had previously taken. Since I felt that it was partly my fault that the students did so poorly the first time, I

needed to give them the opportunity to first learn the essential material more concretely and second improve their grades. I also chose to give the exact same version of the test because then I would have the ability to compare data and measure the level of improvement. This time I was sure to give every student a set of algebra tiles along with the test. I couldn't believe my eyes as students forged ahead without a single one opting to use the algebra tiles. I was so disappointed, knowing that there were some students who clearly would have benefited from their use. In the end, six out of the nine students improved on the second test, two did worse, and one never took the retest.

Overall, for the entire class there was a 4.5% improvement in grade on the second test compared to the first test, which is not necessarily significant. However, looking at the students who showed improvement, mean percentage increase was 11%, an entire letter grade difference. While I cannot know for certain whether improvement was solely based on the fact that we spent more time discussing integers or if the improvement came about as a result of the use of the algebra tiles, I'm pleased that the increase occurred as shown in Figure 1.

Figure 1. Comparison of the number of problems correct for each student on Test #1 and the Re-Test.



Next Topic

As we moved ahead, I modified the set of algebra tiles to include variables, adding x and y tiles (both positive and negative) to the sets to represent unknown variables. I did this so that the students could use the tiles to simplify algebraic expressions by combining like terms. I started by giving the students the algebraic expression 3x+4+2x-2 and asked them to use the algebra tiles to represent the equation on their desk (see Appendix G). Once the students had the

problem set up, I asked them if they could move the tiles around and put things together or group anything. They realized that they could group the tiles together that were the same, which is the principle behind combining like terms. After spending a day solely using the algebra tiles to combine like terms, I taught the lesson writing notes on the board. As I was teaching the lesson, I continued to reference the algebra tiles and showed the students using my overhead set to demonstrate. The students spent a third day combining like terms. I gave every student a set of algebra tiles and five chose to use them. The next day, I asked students to complete an activity involving combining like terms. I put the algebra tiles out on a desk at the front of the classroom and told them that they were there if they wanted to use them. No one opted to do so. Some of the students did very well the first time without using the tiles. However some did not do well at all. Allison, Elli and Carrie got a lot wrong. I explained their mistakes referencing the tiles. Once I explained this, they all decided to use the tiles to correct their errors, and they all did far better the second time actually using the tiles. Elli commented, "I think they would help a lot," and she picked up a set on her way back to her seat. I realized at that point that using the tiles could no longer be an option, and I provided each student with his or her own individual set of algebra tiles each day from that point forward.

During the previous two units, students had not been allowed to use calculators to perform operations. Once we completed integer operation rules, the

students were permitted to use calculators for any computations. In retrospect, I'm sorry that I allowed them to do so. Students become so dependent on calculators that they stop thinking about problems logically. They assume that they push a few buttons on the calculator and out comes the right answer. Unfortunately, they often press the wrong buttons on the calculator and do not ever realize it because they assume the calculator is always right. By allowing them to use a calculator, they also forget the rules that they have learned. They do not need to know the rules for integer operations if they are using a calculator and they often forget them once they stop practicing.

I taught the students how to use the algebra tiles to perform the distributive property. I linked the process to the things that we had previously learned using the algebra tiles. Since we had already done multiplication and combining like terms with the algebra tiles, I continued to reference those processes. I spent the entire period solely teaching the distributive property with the algebra tiles. While I was teaching the unit some of the students used the algebra tiles periodically, but most of them did not. The next day, I reviewed the distributive property and gave the students some problems to work on independently. None of the students used the algebra tiles to complete the problems.

The final topic that I was able to cover within the time frame of the study was dividing a polynomial by a constant. Once again I devoted the first class

period to solely teaching with the algebra tiles. I linked the process to dividing integers and the distributive property. This is one of the hardest topics for the students to understand, so I made sure that I did a sufficient number of examples until they all understood the process. The next day when I gave the students practice problems to work on, none of them used the algebra tiles.

The next test administered was on combining like terms and the distributive property. I was sure to give every student a set of algebra tiles before the test began. Unfortunately, not one student used them while they were testing. Overall the test results were good. The average grade for the class was 76.4%. Only one student failed the test and there was one A and two Bs. From previous experience, this unit is normally very challenging and the grades are usually much lower. So, although the students did not use the algebra tiles as I would have liked them to, I do believe that the reinforcement given with the manipulatives helped to improve the grades overall.

Frustration with Math

After spending seven weeks teaching the students using algebra tiles, they continued to use the tiles only when I explicitly required them to do so. Even then, there were some students who did not really use them. I realized that the students would participate when it was forced participation but did not initiate participation on their own. This made me come to the realization that there were likely other factors beyond my control that I would have to consider before I

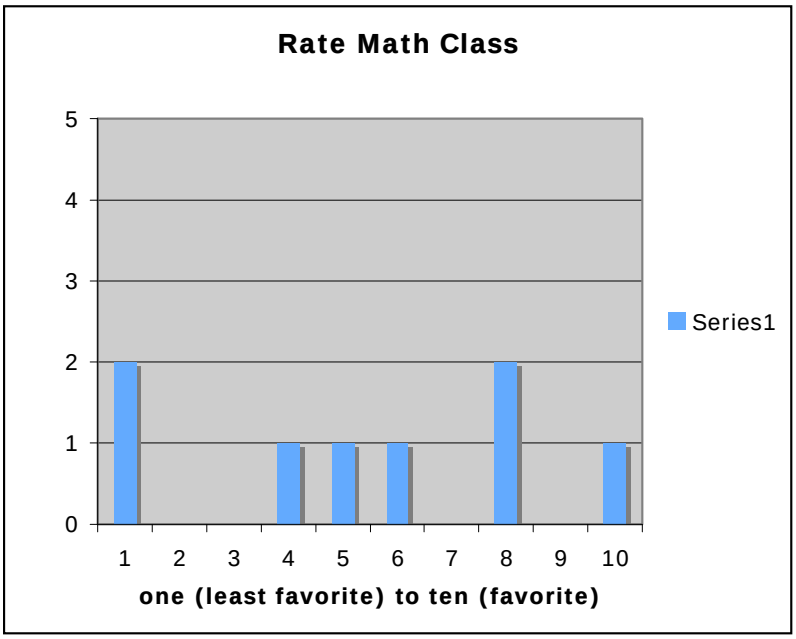
could truly be successful with teaching with manipulatives or trying to improve student motivation and participation.

I created a questionnaire (see Appendix H) that I distributed to the students. I wanted to try to figure out where their frustration with mathematics was originating. Was there something that could be done to improve their attitudes toward math? In fact, I needed to learn more definitively what their attitudes toward math were in the first place.

Much research I read said that students need a strong mathematical basis in order to succeed in mathematics (Burns, 2007; Lubienski, 2007). Students need to have a strong understanding of basic mathematical computations like addition, subtraction, multiplication and division. Therefore, I wanted to see if my students did possess this understanding, and my questionnaire focused on their mathematical background.

I first asked the students to rate math on a scale of one to ten, one being math is their least favorite subject and ten being math is their favorite subject. I then asked the students to show on a scale of one to ten how well they know their mathematical operations, one being not at all and ten being very well. The results of these scales are below.

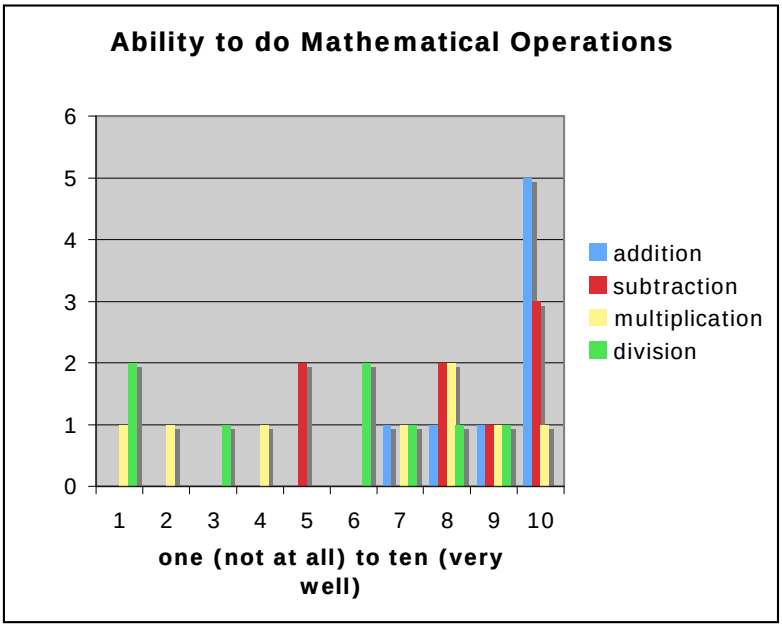
Figure 2. A rating of the students over-all attitude toward math on a scale of 1 -10.



Two students indicated that math was their least favorite subject, and these happen to be the two out of four who struggle the most in the class. One student indicated that math was her favorite subject, and while she does perform well she is not the strongest student in the class. The two who chose eight are among the strongest students within the class. As far as their abilities to perform basic mathematical operations without a calculator, they all felt pretty confident in their ability to add and subtract, but there was less confidence in their ability to multiply and divide. I found this to be unfortunate, because they should feel 100%

confident in their ability to do all mathematical operations by the time they reach high school.

Figure 3. A rating of how well the students know their mathematical operations on a scale of 1 – 10.



When analyzing the remainder of the questions, I found that three students said they regularly use their fingers to add and two said they do so occasionally, indicating to me that they really are not as strong at addition as they suggested.

Five out of the eight students indicated that they did not know their multiplication tables up to twelve. One indicated knowing them but not well, and two indicated not knowing them at all. They felt that the reason that they did not know them was because they did not use them or study them enough. Once they had initially memorized or partially memorized them, they were able to use a calculator and no longer had to remember them.

One student indicated that she is often frustrated when it comes to math. No one really gave any particular events that led to their discouragement in math class, but most of them indicated that they were not "strong" in math and that they had difficulty understanding new concepts. One of the reasons given was that Algebra was too difficult because there were too many rules to remember. Another student admitted to forgetting all of the steps.

After analyzing these questionnaires, I realized that most of my students experienced much frustration when it comes to learning math, which works as an inhibitor. In order for instruction to be successful, I believe that the students need to buy into it as well. If the students feel that they cannot learn math, they are not going to make a genuine attempt to do so. I realized that I would need to find a way to make the students feel a new level of confidence to believe that they can succeed at learning math.

THE STUDY IS OVER

I finished the study by redistributing the same survey that the students had completed at the beginning of the study. The results were similar to those at the beginning of the study with a few major differences (see Table 2). The second time there were more students who felt that math was hard to understand. Along with that, there were fewer students who felt that they got good grades in math. There were also more students who said they like to do hands-on activities in the math classroom. Finally, there was much lower grade expectancy in the post-study survey.

As far as the grade discrepancy, in the beginning of the year the expected average grade was a 91% and at the end of the year that went down to a 77%. I think that this could be due to the fact that they have high hopes in the beginning of the year to do well. Once they have gone through half of the year and gotten grades back, they can better judge how well they will do overall. While I was disappointed with students' diminished confidence in their performance, I was pleased that eight out of the nine students said that they now do like to do hands-on work in math class.

Table 2. End of Study Survey Results

Question		Results
1.	I like math.	Yes – 5 No - 4
2.	I think math is hard to understand.	Yes – 4 No – 4 (1 sometimes)
3.	I feel that math is useful.	Yes – 8 No - 1
4.	I feel that algebra will be useful.	Yes – 5 No - 4
5.	I think that this class will be hard for me.	Yes - 3 No – 6
6.	I like to do hands-on work.	Yes - 8 No - 1
7.	I like to work with partners.	Yes - 6 No – 2 (1 sometimes)
8.	I get good grades in math.	Yes - 2 No – 5 (2 sometimes)
9.	What grade did you get in your previous math class?	Average grade = 82%
10.	What grade do you expect to get in this class?	Average grade = 77%

METHODS OF ANALYSIS

Throughout the process of collecting data, I was continually analyzing the data contained in my field log utilizing a variety of methods. My field log contained a journal of everything that happened in the class each day as well as a series of reflective memos about what transpired (Holly, Arhar & Kasten, 2005). Within the field log, I recorded personal reflections by inserting brackets around passages that were describing my personal observations. There was a large margin on the left side of the entire field log. This margin allowed me the room to sort my notes with the use of codes. I developed one and two-word codes that described important ideas throughout the notes. By labeling with the codes I was better able to recognize patterns that were occurring throughout the notes. I put the common codes into bins. I used the bins to create a theme statement for each bin (Ely, Vinz, Downing, & Anzul, 1997). These theme statements formed the preliminary findings of my study (see Figures 4 & 5).

In addition to conducting an analysis of my field log, I also analyzed student interviews, surveys and questionnaires. I tallied all of the responses to the surveys and questionnaires in order to determine a consensus of the answers given. I also noted any common responses to questions. I then put the data into a spreadsheet and created tables to represent the results.

Figure 4. Bins from Field Log

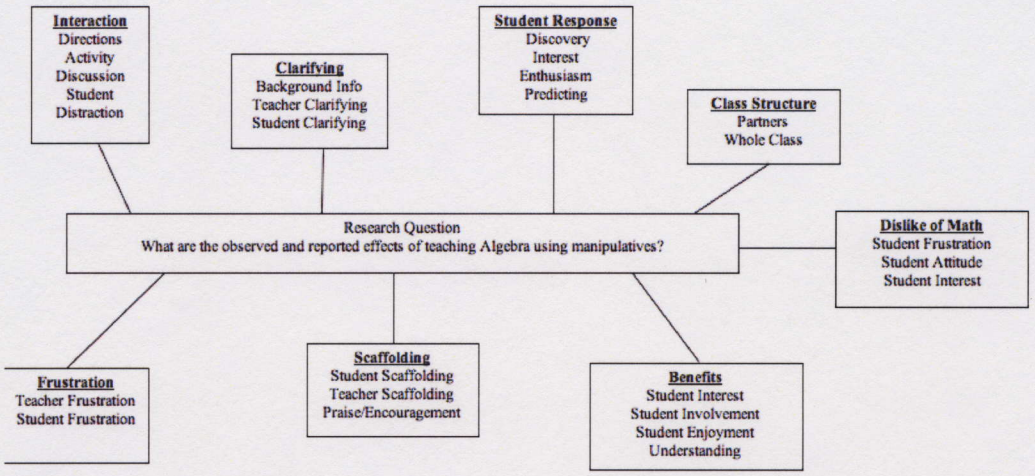


Figure 5. Theme Statements developed from bins.

Theme Statements:

1. Student interaction promotes involvement in the class.
2. Clarifying helps make activities run more smoothly within the class.
3. Hands-on learning promotes direct student discovery and interest. An increase in interest can improve student achievement.
4. Class structure is essential in creating an atmosphere conducive to the activity at hand.
5. Manipulatives serve an important scaffolding function.
6. Student frustration and prior attitudes toward math may lead to disengagement.
7. Frustration on both the part of the teacher and the student is to be expected when trying to implement a new classroom structure.

I also analyzed student work, including tests and quizzes. I looked at each assessment to see if there were any common problems that more than one student was getting wrong. I also looked at the overall grades that were received and determined an average performance level for the class.

Finally, I analyzed data through reflective memos I wrote as I read the works of Dewey (1997), Freire (2003), Vygotsky (1978), and Delpit (2002). I found quotes in each of these writings and analyzed how they applied to my study.

FINDINGS

The most important theme that I found throughout the study was that *Student interaction promotes involvement in the class*. This was evident when students were working with the manipulatives. When students were using the algebra tiles, they were involved in finding their own solutions to problems. They were working on their own to come to conclusions. Students were actively discovering. According to Weinstein (2003) teachers need to make sure that students are actively involved and time spent doing work is meaningful and appropriate (p. 159).

In many cases, I did not give the students direct instruction on how to use the algebra tiles to perform the mathematical computations at hand. I simply guided them and allowed them to discover the process on their own. Once they had the opportunity to discover on their own, I would display for them how to complete the tasks with the tiles. However, I did not do this on my own, I asked the students to demonstrate for the class what they had ascertained. “Now, all principles by themselves are abstract. They become concrete only in the consequences which result from their application” (Dewey, 1997, p. 20). Within this quote, Dewey is saying that in order to have a true understanding of any principle introduced, the concepts must be applied to something. Ideas are abstract until something happens to make them concrete.

Algebra is abstract. Learning about variables and manipulating them is not immediately relevant to students and their lives and it is often hard for them to comprehend. In order for that abstractness of the ideas that were taught in class to become meaningful, I used manipulatives. The students used hands-on activities to get a better understanding of the topics that were taught. Once they could apply what they learned with the manipulatives to the lessons that were taught, they were able to have a stronger understanding of the topics.

By allowing students to use the algebra tiles first to discover mathematical concepts, they were able to infer their knowledge into the lesson that followed. Since the students had an understanding of what was about to be taught, they were able to answer questions during the lesson that tied the algebra tiles to the step-by-step processes that were taught. This all promoted student interaction and involvement in the class. By allowing the students to learn in this way, I was allowing them to progress through what Vygotsky (1978) calls the Zone of Proximal Development (p. 86). Students first learn under guidance from the teacher but then as they progress, they are able to do the same tasks on their own without assistance.

A very important concept to keep in mind when implementing any new activity within your classroom is that *Clarifying helps make activities run more smoothly within the class.* Whenever the normal routine within the classroom is changed, there is going to be a change within the structure of the classroom. In

order to ensure that the activities run smoothly the teacher needs to be certain to give clear concise directions from the start. According to Weinstein, within a typical 42-minute class period, only about half of that time is actually engaged time for the students (p. 159-160). Therefore, I wanted to utilize as much time as possible.

The first time the students used the algebra tiles I had them separate all of the tiles into common piles. They had no idea what they were going to do with the tiles at this point; they simply followed directions and separated them, allowing them to more easily use the tiles to represent the problems that they were going to be doing. This was a good decision because after that initial day, the students separated their tiles every time they used them without me having to tell them, making each activity run more smoothly.

Each time the students used the manipulatives, I was sure to explain to them what they were expected to do. I would first explain to them the goal of the activity. I would then give them step-by-step directions for achieving that goal. I would not move on until every student had mastered the previous step. By giving the students clear instructions I was able to maximize the class time spent doing manipulative activities. I did not have to waste time continually going over directions.

Hands-on learning promotes direct student discovery and interest. An increase in interest can improve student achievement. Previously I wrote about

giving the students the opportunity to discover the processes of doing mathematical computations on their own before demonstrating for them. When the students were using the manipulatives to discover their own understanding, they showed a great deal of interest. They all worked hard at trying to accomplish the task at hand. Students asked intuitive questions and made comments revealing their interest in the activities.

Through their own discovery and interest, many of the students were able to improve their level of achievement. This was evident in the comparison of test scores for integer operations (see Figure 1). When students took the test the second time after using the manipulatives, six out of eight students improved their grade, and the average increase in grade was 11%.

Also, in my opinion, the students had a better overall understanding of integer operations and combining like terms. I have been teaching these topics to on grade level students for seven years at this point. Students often struggle with these concepts and even if they master them for a test, they all too often forget them soon afterwards. I found that these students were better able to retain this information. When I asked questions linking previous knowledge, the students were able to answer those questions quickly and accurately.

In addition to clarifying, *Class structure is essential in creating an atmosphere conducive to the activity at hand.* The most important thing to keep in mind when implementing manipulative activities is that the structure of the class

is going to change. The teacher needs to make sure that the classroom is set up so that implementing these activities is done easily.

I had my classroom set up so that students were paired together at seats, which allowed for them to always have a partner that they could collaborate with when they were doing an activity. This was an advantage because then students were able to learn from each other rather than always asking me. It was an informal session of peer teaching and learning. This helped to increase their level of understanding because they were explaining the process to someone else.

Following the suggestions of Joyner (1990) to make distribution and clean-up as smooth as possible, I also made sure that each algebra tile set was in its own individual Ziploc baggie and they were placed in a bin in the front of the classroom. This made for easy access for the students. Retrieving and returning the algebra tiles was quick and easy. This allowed for more time to use them. There was no wasted time with distribution and clean up. It also allowed continual access to the algebra tiles for the students.

Manipulatives serve an important scaffolding function. By continually building each lesson from the previous, the students were able to create a strong basis of learning.

Once I introduced the algebra tiles to the students, they were the sole form of manipulatives used within the classroom. Each activity built upon what the students had previously learned to do. Not only did the students need to remember

how to do previous problems, but they also needed to apply that knowledge to perform subsequent problems. Burns (2007) suggests that students will succeed in mathematics if they see a connection in what they are learning and they are building on their prior knowledge. I applied this knowledge to the use of manipulatives. I kept a level of consistency by modifying the algebra tiles so that they could be utilized within all of the activities the students did.

There are some stumbling blocks that need to be considered as well. First, *Student frustration and prior attitudes toward math may lead to disengagement*. Because I chose to conduct this study in a homogeneously grouped low-level math class, I was working with students who already felt some animosity and opposition toward math. When responding to the initial questionnaire, five of the nine participating students commented that they were not good at math, the typical attitude of the students placed within this level. I had to try to get these students past this idea and accept the fact that they could do well in math, and doing so was not always easy.

At times, students would stop working because they did not remember how to use the tiles correctly, become confused, and simply shut down.

Finally, *Frustration on both the part of the teacher and the student is to be expected when trying to implement a new classroom structure.* This was evident when students asked why they could not just use a calculator. By the time students get to high school they have been using a calculator for so long, they

don’t know how to survive without one, and they may become frustrated when it is taken away form them.

When I guided students to use the manipulatives, they would for the most part do so. However, when it came time for them to use the manipulatives on their own, many did not. This was the source of the biggest frustration for me. I felt that if the students would just give this a try, many would be successful. This is what led me to the conclusion that there was something beyond my control that would have to be explored. These students had some predisposed ideas about math that needed to be addressed before a study like this could be completely successful. Weinstein puts forth the idea of an expectancy-times-value model (p.188). She stresses that there must exist both a value in an activity as well as students must feel that they can be successful. If both of these concepts do not exist, it is difficult to keep students motivated. As teachers, we must first make students feel that they are in a safe environment where they can succeed and we must make them recognize the value of the work that we ask them to do.

WHERE DO I GO FROM HERE?

After completing my study, I now have additional questions about how I might improve my classroom structure. This process has changed the way that I view my classroom. As a result of conducting action research, I am now always questioning the effects of what I am doing and thinking about how I can improve a lesson or series of lessons to get the students more involved. I definitely plan to continue to use manipulatives within the class, and I will continue to use the algebra tiles.

I believe that the manipulatives helped to engage the students and overall helped them improve their learning. However, the fact that the students only used the manipulatives when I directly encouraged them do so was a bit discouraging. Therefore, the first new question that arose for me centers on how to create an environment where the manipulatives are a constant focus within the classroom. I want the students to become comfortable with using them and want to use them even when I might not explicitly require them to do so. I think that beginning with the use of algebra tiles from the start of the course will help in this matter. The fact that I did not use them immediately may have hurt the process. I think that the students may have felt that they already knew how to do integer operations before I introduced the tiles, so they did not think that they needed to use them. I am also considering requiring all students to use the tiles on every assignment, quiz, and test until they have achieved a grade of a B or higher.

A second issue that arose within this study was the idea that too many students feel that they are not good at math, discouraging them from trying to do well. It is like they have given themselves permission to not do well because they think that they cannot succeed in a math class. I would like to find a way to help them overcome this idea. While math educators have a long way to go to eliminate mathematics phobia, I know that I may create new activities that build upon themselves to allow the students to achieve a greater level of success within the classroom. For example, I could create mini lessons on integers and continue to incorporate them into each class period until they master them. Another possibility would be for me to give short quizzes each day to boost their sense of accomplishment. I will also create quizzes that assess the students understanding of concepts. These quizzes will not be assessing their mathematical abilities; they will assess their comprehension. This will also give me the opportunity to see where I would need to make changes in instruction if the students do not understand.

In addition, I will allow time for more cooperative learning and discovery learning. When students work in groups, they help and encourage each other. If a student is able to help explain something to a peer, there may be more of a feeling of accomplishment. Through discovery learning, I want to try to give students time to invent their own formulas. The success that students will feel if they can

come up with correct conclusions on their own could have an enormous effect on their attitudes.

After giving the students the questionnaire at the end of the study, I found that they are still not as strong as they need to be in their mathematical operations. I would like to find a way to help the students improve these skills. Unfortunately, the students have become so dependant on calculators that they forget their basic skills. I would like to find a way to help them improve those skills that they have relied on the calculator to do. I think that if I could reinforce these skills at the beginning of the year before starting with the algebra tiles, students may find greater success. Again, I will use short quizzes to assess the students' abilities and continue to do so until each student has mastered these skills.

I feel that using manipulatives is a form of differentiated instruction through inquiry-based learning. There are other aspects of differentiated instruction that I could implement to help improve achievement. I will start by determining in the beginning of the year what type of learners my students are so that I can focus on each students strengths and weaknesses. I will create learning centers with varying levels of problems. The students will be able to work at their own pace. I will also incorporate flexible grouping. Although I had students grouped for the study, the groups were always the same. Finally, I will try to use forms of alternative assessment, possibly allowing students to chose their form of assessment at times.

This study has definitely opened the doors for me to provide some important new opportunities for students to learn mathematics within my classroom. Implementing manipulatives is clearly something that I will continue to do over the years to come. As a result, my students will be more motivated and with greater participation benefit with a superior knowledge of what they are learning.

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APPENDIXES

Appendix A

MORAVIAN COLLEGE
A SMALL NATIONAL TREASURE
1742

Department of Education
1200 Main Street
Bethlehem, Pennsylvania 18018-6650
TEL 610 861-1558
FAX 610 861-1696
WEB www.moravian.edu

Dear Mr. [redacted]

As a requirement for a graduate course I am taking at Moravian College, I will be studying the effects of using manipulatives in the classroom. I am writing to ask permission to perform the study and use the data I collect in my research report. Participation in this study involves only regular classroom activities and does not require any additional work. There are no anticipated risks in this study. All students will be involved with the activities because it is a part of my regular Algebra curriculum. However, participation in the study is entirely voluntary and does not affect your child's grade. If you have any questions, you may contact my faculty sponsor, Dr. Joseph Shosh, by phone at 610-861-1482 or by email at jshosh@moravian.edu.

The purpose of the study is to determine if hands-on student participation in learning will increase student understanding. The study will take place within my Applied Algebra I classroom and will begin on September 4 and continue through December 20. I will be using manipulatives (hands-on activities) in the classroom to increase student participation in learning. During the study, I will collect various forms of data to determine whether the use of manipulatives was successful. Possible types of data I will collect include: observations, surveys, and students assessments. At the conclusion of the study all data will be destroyed.

Benefits of participating in this study include increased participation in student learning, concrete evidence of the uses of mathematics, and hopefully increased understanding. Understanding Algebra is necessary for students to succeed in future math classes. Only my professor, teacher research colleagues and I will have access to the data collected in this study. Participation in this project is strictly confidential. I will use pseudonyms to protect student's identities and all materials will be kept in a locked location.

Use of data from the study is voluntary. Parents may contact me at any time if they do not wish to have their child's data included in the study. Any student may withdraw without penalty or consequences and no data will be collected on your child.

Thank you for your time,

Tonia Salamone

Tonia Salamone

Please sign below to indicate your approval of this study.

I give permission for my school to participate in this study. I have read this form and understand it.

XXXXXXXXXXXXXX
Signature of Principal

4/30/07
Date

Appendix B

1742

MORAVIAN COLLEGE

August 31, 2007

Tonia M. Salamone
203 E. Laurel Ave.
Pen Argyl, PA 18072

Dear Tonia M. Salamone:

The Moravian College Human Subjects Internal Review Board has accepted your proposal: "Increasing Student Motivation and Participation through the use of Manipulatives in and Algebra 1 Classroom." Given the materials submitted, your proposal received an expedited review. A copy of your proposal will remain with the HSIRB Chair.

Please note that if you intend on venturing into other topics than the ones indicated in your proposal, you must inform the HSIRB about what those topics will be.

Should any other aspect of your research change or extend past one year of the date of this letter, you must file those changes or extensions with the HSIRB before implementation.

This letter has been sent to you through U.S. Mail and e-mail. Please do not hesitate to contact me by telephone (610-861-1415) or through e-mail (medwh02@moravian.edu) should you have any questions about the committee's requests.

Debra Wetcher-Hendricks
Chair, Human Subjects Internal Review Board
Moravian College
610-861-1415

1200 MAIN STREET • BETHLEHEM, PENNSYLVANIA 18018-6650 • (610) 861-1300

Appendix C

MORAVIAN COLLEGE
A SMALL NATIONAL TREASURE
1742

Department of Education
1200 Main Street
Bethlehem, Pennsylvania 18018-6650

TEL 610 861-1558
FAX 610 861-1696
WEB www.moravian.edu

Dear Parent or Guardian,

As a requirement for a graduate course I am taking at Moravian College, I will be studying the effects of using manipulatives in the classroom. I am writing to ask permission to use the data I collect from your child in my research report. The principal of the school has approved this study. He may be contacted by phone at 610-250-2481. Participation in this study involves only regular classroom activities and does not require any additional work. There are no anticipated risks in this study. All students will be involved with the activities because it is a part of my regular Algebra curriculum. However, participation in the study is entirely voluntary and does not affect your child's grade. If you have any questions, you may contact me at any time. I can be reached at the school by phone at 610-250-2481 or by email at salamonet@eastonsd.org. You can also contact my faculty sponsor, Dr. Joseph Shosh, by phone at 610-861-1482 or by email at jshosh@moravian.edu.

The purpose of the study is to determine if hands-on student participation in learning will increase student understanding. The study will take place within your child's Applied Algebra I classroom and will begin on September 4 and continue through December 20. I will be using manipulatives (hands-on activities) in the classroom to increase student participation in learning. During the study, I will collect various forms of data to determine whether the use of manipulatives was successful. Possible types of data I will collect include: observations, surveys, and students assessments. At the conclusion of the study all data will be destroyed.

Benefits of participating in this study include increased participation in student learning, concrete evidence of the uses of mathematics, and hopefully increased understanding. Understanding Algebra is necessary for students to succeed in future math classes. Only my professor, teacher research colleagues and I will have access to the data collected in this study. Your child's participation in this project is strictly confidential. I will use pseudonyms to protect your child's identity and all materials will be kept in a locked location.

Use of data from your child is voluntary. You may contact me at any time if you do not wish to have your child's data included in the study. Any student may withdraw without penalty or consequences and no data will be collected on your child. Please inform me in writing, if you no longer want to have your child participate and I will remove their data.

Thank you for your time,

Tonia Salamone

Tonia Salamone
Please check the appropriate box below and sign the form:

☐ I give permission for my child's data to be used in this study. I have read this form and understand it.

☐ I do not give permission for my child's data to be included in this project.

_____ _____ _____
Student's name *Signature of Parent/Guardian* *Date*

Appendix D

Algebra I Survey

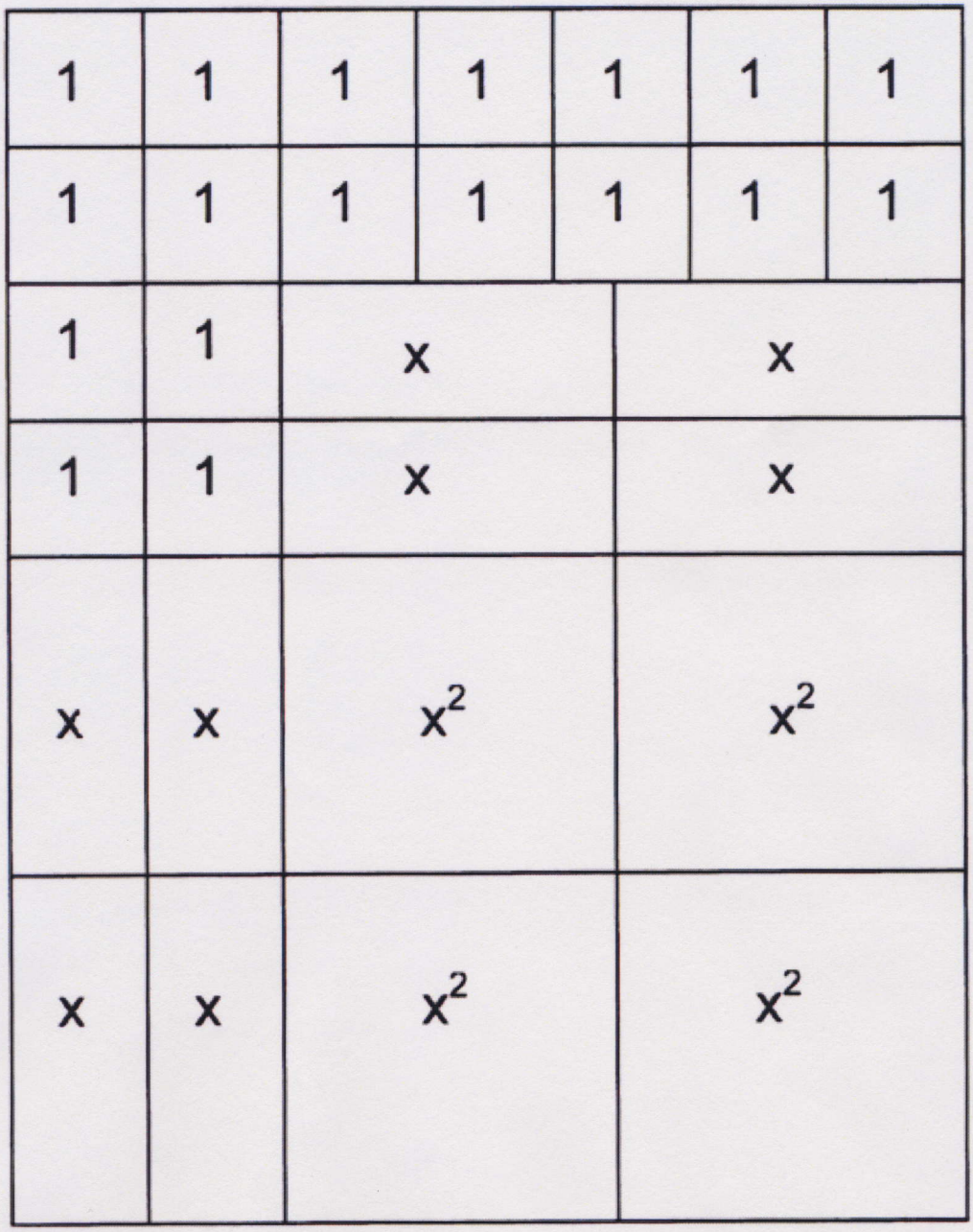
Please complete the following survey by circling yes or no for each question.

Thank you for your cooperation.

1.	I like math.	Yes	No
2.	I think math is hard to understand.	Yes	No
3.	I feel that math is useful.	Yes	No
4.	I feel that algebra will be useful.	Yes	No
5.	I think that this class will be hard for me.	Yes	No
6.	I like to do hands-on work.	Yes	No
7.	I like to work with partners.	Yes	No
8.	I get good grades in math.	Yes	No
9.	What grade did you get in your previous math class?	_____	
10.	What grade do you expect to get in this class?	_____	

Appendix E

Algebra Tiles

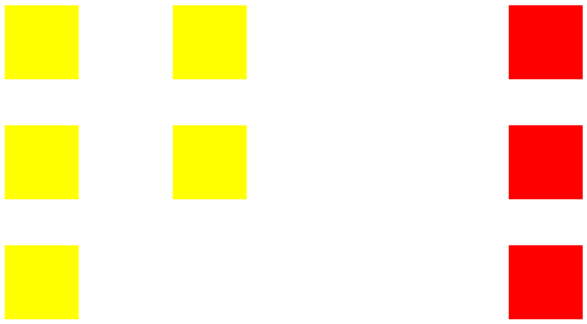


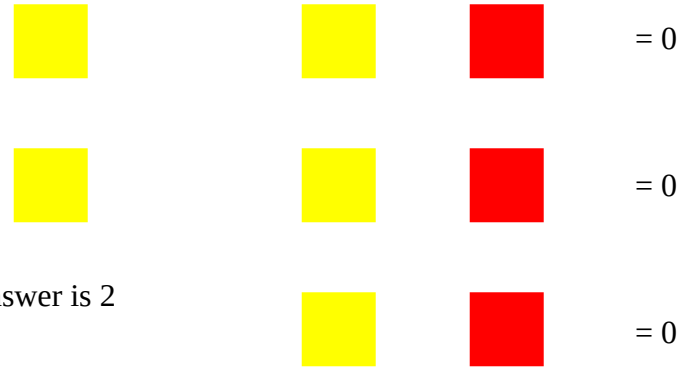
Appendix F

= Positive

= Negative

5 + (-3)





= 0

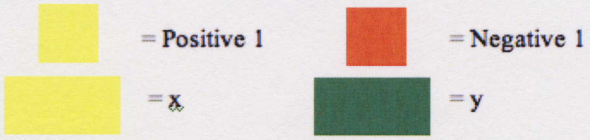
= 0

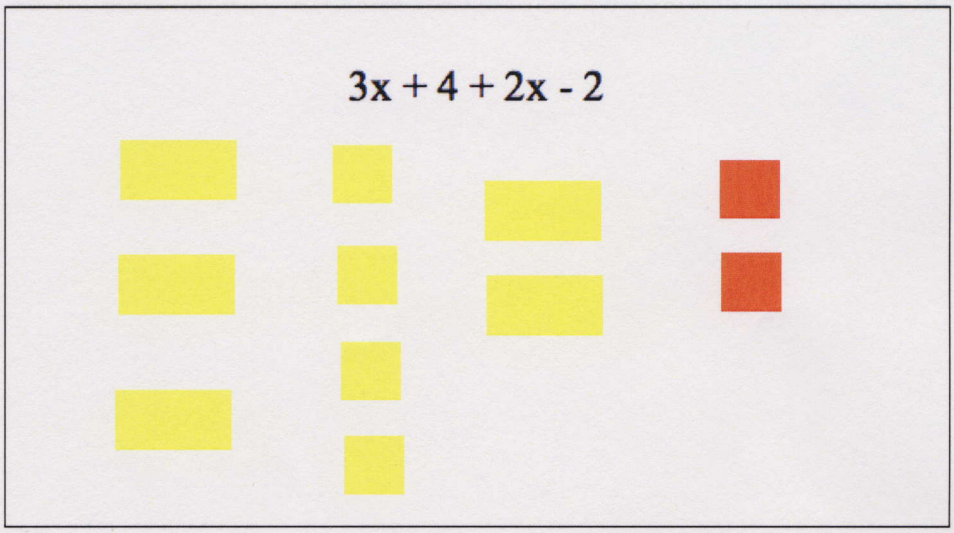
= 0

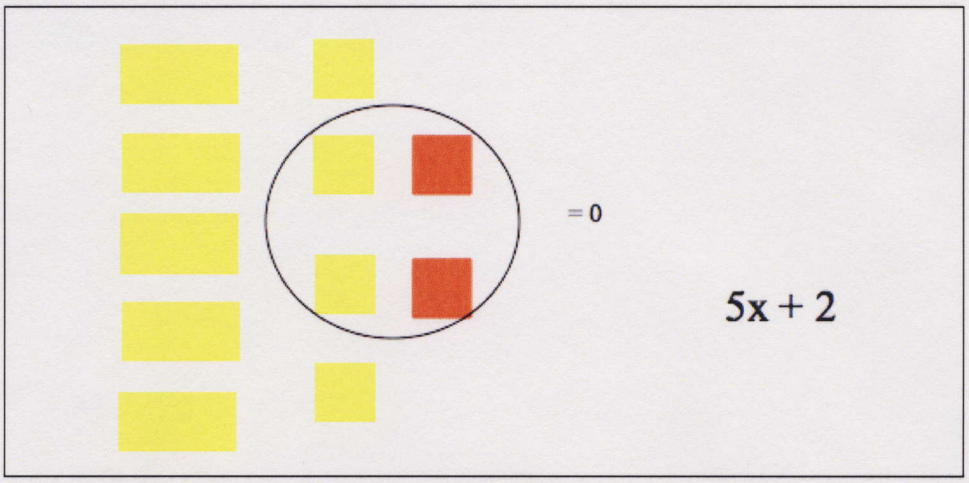
Answer is 2

Appendix G

Variable Expressions







Appendix H

On a scale of 1 - 10 rate math: 1 being least favorite subject, 10 being favorite subjec

1 2 3 4 5 6 7 8 9 10

On a scale of 1 - 10 how well can you do each of the following without a calculator?
1 not at all, 10 very well

add	1	2	3	4	5	6	7	8	9	10
subtract	1	2	3	4	5	6	7	8	9	10
multiply	1	2	3	4	5	6	7	8	9	10
divide	1	2	3	4	5	6	7	8	9	10

If you can't use a calculator, do you count using your fingers?

What is your most difficult topic in math? Why?

When do you think math started getting difficult for you?

Is there a particular time you remember that you had a bad experience with math?

Do you know all of your multiplication tables through 12 without using a calculator?

Why do you feel you do not know you multiplication tables?

Why do you feel that you are in an Applied level math class?