Achievement in Problem Solving

Capstone B: Action Research

David Friebele

Marygrove College

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Abstract

This Action Research Project is meant to investigate the effects of incorporating research-based instructional strategies into instruction and their subsequent effect on student achievement in the area of problem-solving. The two specific strategies utilized are the integration of manipulatives and increased social interaction on a regular basis. The project took place over eight weeks, beginning January 11th, 2010 in the sixth, seventh, and eighth grade classes at the Petworth campus of the Center City Public Charter School (CCPCS). CCPCS Petworth campus is located in NW Washington DC, its students are of low socio-economic status, and are all minorities.

The tools used to collect data about these strategies included summative assessments, anecdotal field notes, journal entries, surveys, and self-evaluation rubrics for students. After implementation, summative assessments scores increased, student confidence levels improved, and their problem solving strategies were broadened while their critical thinking skills improved as well.

Introduction

Students need the skill of problem solving. Not only do district and state standards mandate the teaching of problem solving under No Child Left Behind, but it is a necessary social skill that transcends academic, social, political, and professional boundaries. As a teacher, I have witnessed students' struggle with problem solving and critical thinking. This project is based on my experience of teaching these vital skills during the nine month academic year for the last four years at the middle school level.

Recently I was hired as the mathematics teacher for Center City Public Charter Schools (CCPCS) district in Washington D.C. at the Petworth campus. CCPCS has recently developed a rigorous curriculum that encompasses five strands, or categories of content. These strands include number sense, data analysis and interpretation, geometry, measurement, and algebra. In each of these categories there exist several standards requiring the application of knowledge and skills to problem solving tasks. Not only has the curriculum changed, but so has the textbook series that CCPCS uses. CCPCS has adopted *Connected Mathematics* published by Pearson, which focuses more heavily than previously used resources on mathematical reasoning, problem solving, and communication. Therefore, the middle school mathematics courses of CCPCS require a great deal of transfer of knowledge and skills by the learner.

Problem solving requires several prerequisites of the learner. Before approaching problem solving tasks, students must be proficient at the skill required to successfully solve the given problem. Specific to word problems, students must understand vocabulary and be able to correctly identify words that indicate operations. Even more challenging to overcome is students' indifference and distaste for problems in context. I have experienced my middle school students' disdain for problem solving and I hope to remove their negative sentiment over the course of this project.

My middle school students make up a significant fraction of CCPCS. CCPCS is currently in its second year in existence. Forced with the decision to close or convert from parochial to public charter, the six schools in CCPCS are located in Washington, DC and their populations are considered urban. Because these schools accept all students, CCPCS has experienced a 5% growth since conversion. Particular to the students I teach, 85% are African American, 15% are Hispanic, of which 10% are considered English Language Learners, and 5%

of whom receive support from the ESL instructor. The majority of learners come from working-class families and are considered low socio-economic status. Among these students, 6% have Individual Education Plans and receive extra support through a plug-in model. An Inclusion Specialist assists students who perform below grade level during instruction. She is present in my classroom at least once a week for all grades and aides immensely with differentiation of instruction.

Pertinent to differentiated instruction is the use of manipulatives. I assume that the use of manipulatives during this project will increase students' abilities to conceptualize mathematical ideas and will improve the speed and accuracy in which students are able to problem solve. I also assume that students will learn from each other when interacting socially during class. I believe that I will be able to help students overcome their fears of and remove the overwhelming anxiety that arises when challenged with word problems and problem solving tasks. My students will hopefully become empowered by the success they experience, become more confident in their mathematical skills and in turn become more motivated to overcome more problem solving challenges. My hope is that they will also able to understand the value of effort in achievement.

Area of Focus Statement

The purpose of this study is to describe the effects of implementing research-based teaching strategies on students' achievement in mathematics. This area of focus statement fulfills my beliefs about action research in that it can benefit my practice and it is something that I would like to change or improve, it is within my parameters of my control, and can improve the lives of my students, which is the core of my rationale for becoming a teacher.

Review of Related Literature

As a native to Washington D.C., I have witnessed the struggle of urban communities, families, and children. As a young teacher in the city with one of the worst public school systems in the country, I strive to provide quality education to children because I want them to succeed in their academic, personal, and professional lives. I do not want them to face the same challenges that some of their parents did, such as raising several children as a single parent, working to support their families instead of pursuing higher education, or involvement in drugs, gangs, and violent crimes. I believe that the lack of equity in education is an issue that affects many urban communities and it is my responsibility to close the achievement gap that exists because of its existence. By practicing effective pedagogy in mathematics, I feel that I can supply students with opportunities to achieve to their highest potential and these research-based strategies provide a framework for the related literature to be considered here.

Muir, T (2008). Principles of practice and teacher actions: Influences on effective teaching of numeracy [Electronic Version]. *Mathematics Education Research Journal*, 20, no. 3, 78 – 101.

Muir (2008) asserts that the mastery of numeracy transfers to many real life situations and this transfer can ease nonacademic problem solving. She outlines factors that influence effective teaching practice, which include teacher knowledge, teacher beliefs, and constructivism. She also underscores the importance of student choice in assignments and tasks, the use of manipulatives, and modeling.

While the author supports my beliefs about teaching, it is interesting to see this information through an action research lens. Muir specified examples from her study of when the student choice was detrimental to the students' conceptual knowledge and understanding, which is relevant to my research because I can heed her warning when planning for group activities. I will start by omitting choice from the activities and slowly integrate options for students after routines and expectations are established and adhered to.

Annenburg Media (1997 – 2009). Insights into algebra. In *Benefits of Cooperative Learning.* Retrieved October 15, 2009, from http://www.learner.org/workshops/algebra/workshop1/teaching.html

The authors summarize the benefits of cooperative learning. During cooperative learning, students actively participate. Rather than being passive recipients of information, "they are generally enthusiastic about their own learning. Students take ownership and responsibility when working as part of a team - possibly because other group members will be affected by their actions. As a result, students gain a deeper understanding of mathematics" (Leiva, M. 1997-2009). Leiva asserts that cooperative learning increases academic achievement, improves social skills, increases motivation, improves behavior, and creates positive attitudes towards school.

While this article does support the promising practice of social interaction among students, it allows me to see cooperative learning through Leiva's eyes. I had never considered that students working in groups can answer questions simultaneously and at a more rapid rate than can one classroom teacher. Other promising practices in this article include changing the grouping of students frequently, keeping the size of the group small, and reconvening as a class to share, compare and contrast the different methodologies of each group's solving process.

Also presented in this source are interesting perspectives about the use of manipulatives. Included is an old Chinese proverb: I hear, and I forget; I see, and I remember; I do, and I understand. The authors describe manipulatives as a physical link to abstract concepts. They compare the success rates of students who use manipulatives in the classroom to those who don't when learning linear functions, variables, and exponents.

The author's descriptions of student success align with my biases as I approach the data collection phase of this project as they describe students' abilities to conceptualize abstract models and explain their thinking verbally and in writing

Opitz, C. (2009) Video: *How to teach math as a Social Activity*. Retrieved October 15, 2009, from http://www.edutopia.org/math-social-activity-sel-video

This video outlines a master teacher's techniques for engaging his students in cooperative learning. His techniques include many important categories of a socially-based classroom. First, he develops a contract with the students that include speaking, listening, thinking, and behavior so that they are accountable and buy in to the classroom procedures. Second, he has students work in pairs to solve a problem, and then asks students to model positive and effective discussion about mathematics with the "fish bowl" activity.

Seeing cooperative learning through the lens of another middle grade math teacher is enlightening. While I hold the same beliefs as the teacher in the video, I have not attempted some of his techniques. One promising practice is his use of the "fish bowl" to monitor student language, conversation, and critical thinking. One of my assumptions in approaching this project was that if I increase cooperative learning and social interaction in the classroom, then I will be increasing the opportunity for disruptive behavior. However, structuring the social interaction in the "fish bowl" format could eliminate those behaviors and even improve the overall behavior of students during math class. If my students observe their peers engaged in meaningful discussions about the content of mathematics, then it could encourage them to participate and contribute to their own groups' progress when problem solving.

Moyer, Patricia S. (2004). *Are we having fun yet? How teachers use manipulatives to teach math* [Electronic Version]. Springer Netherlands, 47 (2), 175 – 197.

Moyer conducted a study of how teachers use manipulatives to teach math. Her study was based on the theories of Piaget, Vygotsky, and Vienes, and the research of Cobb whose works collectively form the foundation suggest that children learn better when they have materials to support the construction of knowledge.

Although Moyer's research mainly studied how teachers use manipulatives in the classroom, her closing comments directly coincide with my beliefs. She holds that teachers must know their content well and not use manipulatives to simply make math fun, but to effectively represent relationships, algorithms, and patterns. She states that the incorporation of manipulatives into instruction "requires teachers to guide students to translate between representations in the form of mathematical objects, actions and abstract concepts so that students can see the relationship between their knowledge and new knowledge" (p. 194).

Education Alliance, The. (2006). *Closing the achievement gap: Best practices in mathematics.* 1-21.

This resource outlines the best practices in teaching mathematics. The mathematics reform movement, standards-based instruction, best practices, and the call for professional development to improve instruction are all described. In the table at the end, several suggestions and examples of learning experiences are given.

The article highlights several important contextual facts for my project. First, “in the areas of measurement, geometry, data analysis, probability, and algebra, “nationally, only 30% of eighth graders were deemed proficient” (p. 1). The article describes that the poor performance in math among U.S. middle school students can be traced to the method used to teach math at the elementary level. The focus in these grades is on specific problems and not on building the foundations necessary for understanding higher level math. However, “these foundations can only be built with a mathematics program that teaches concepts and skills, and problem solving” (p. 2).

Specific to my teaching practices and beliefs, the article asserts that “Teachers must ensure that the use of ‘real-world’ contexts for teaching mathematics maintains a focus on mathematical ideas (p. 5). This practice is especially important to the engagement of my students throughout the project. If I connect the mathematical content to real world situations and make the learning meaningful to students, then engagement in the learning experiences will be increased.

The Education Alliance also comments on the use of manipulative in instructions. According to them, the use of manipulatives “helps students understand mathematical concepts and processes, increases thinking flexibility, provides tools for problem-solving, and can reduce math anxiety for some students” (p. 8). I hold the same belief and the reduction of anxiety is beneficial to my students in particular as many of them have admitted to dismissing mathematical tasks because they seem daunting, complex, and challenging.

Gersten, R., Beckmann, S., Clarke, B., Foegen, A., Marsh, L., Star, J. R., & Witzel, B. (2009). Assisting students struggling with mathematics: Response to intervention (RtI) for

elementary and middle schools [Electronic Version]. *National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education*. Retrieved October 24, 2009.from http://ies.ed.gov/ncee/wwc/publications/practiceguides

This article supplies guidelines for interventions for struggling students. Since many of my learners are currently below grade level in their mathematical performance, the strategies outlined in this article should be considered when involving struggling students in middle school mathematical content. Gersten, Beckman, Clarke, Foegen, Marsh, and Star (2009) assert "Whenever possible, links should be made between foundational mathematical concepts in the intervention and grade-level material" (p. 7). Manipulatives help students make these connections.

Anonymous (2006). Math wars. *Professional Association of Georgia Educators, 8.*

This resource gives a brief history of the reform movement in mathematical pedagogy and a description of the two schools of thought that have clashed over the past decades. The two major camps are Traditionalists and Reformers or Progressives. Traditionalists believe that engaging students in repetitive exercises will achieve proficiency because thirteen years of schooling is not enough time for students to develop their own methods for problem solving. Reformists stress conceptual thought and learning through discovery. As a teacher that derives strategies from both sides of the argument, I am enthusiastic to be involved in the issue especially because I can contribute to the research in this area. As the author describes, "There is no substantive research on how to best teach students to excel at problem solving," so any research done in my classroom can support, or deter, implementing certain strategies into instruction (p. 8).

Aligned with my personal teaching philosophy is one key point that is highlighted in the article. The author states that "The reformers say the NCTM Standards motivates students and prepares them for the math they will use in life and in the workplace." (p. 8). As a believer in active participation on the part of the student in the problem solving process, I consider this article important to my research. I was taken back and excited to discover that little research exists on the most effective means of improving students' problem solving skills. It helps me to see the problem I am investigating through the author's eyes and makes clear the implications for my action research. I will be one of few who has experimented with different teaching strategies, and collected data in this area.

Daro, Phillip. (2006). Math warriors, lay down your weapons. *Education Week, Feb. 15.*

The author describes the lack of elementary teachers to incorporate problem solving skills into their instruction. The relationship between problem solving and basic skills is discussed and the need for both is underscored. Also, the author calls for improvement of teacher's recognition of misunderstandings among learners to identify their learning levels, to build on prior knowledge in order to heighten their critical thinking skills.

As mentioned before, elementary teachers often do not prepare students for the types of problem solving tasks that are required by state and district middle school mathematics standards. Daro explains, "When students eventually get to algebra and geometry, their performance hits a wall because they don't understand underlying concepts of arithmetic on which algebra and geometry are based." (Retrieved at http://www.broward.k12.fl.us/k12programs/math/15_ARTICLE-Math%20Warriors.pdf on 9/19.09). Therefore, it is imperative that students' misconceptions be removed the first year of middle school so they will be prepared for more challenging problems in the future. As Daro asserts, “A particular concept may have worked effectively for problems in grade in which they were taught it, but does not work for problems in the higher grades” Retrieved at http://www.broward.k12.fl.us/k12programs/math/15_ARTICLE-Math%20Warriors.pdf on 9/19.09).

Loveless, T. (2006). How well are American students learning? *Brown Center report on American Education, II,* 1 – 30.

The report outlines achievement scores over the last two decades in mathematics and language arts, and highlights reasons for data patterns from test scores ranging from teaching practices to student motivation. Then the report compares students’ happiness in school and how it aligns to their performance in different content areas and asks whether states are really reporting their scores correctly.

Aside from assisting students with visualization of mathematical content, manipulatives create engagement enable students to be successful during problem-solving tasks, building their self-confidence and enjoyment of the material. As Loveless describes, this is important because “Joyous, confident kids studying a curriculum relevant to daily life will learn more than children without the benefit of such positive experiences” (p. 13).

Skott, J (2004). The forced autonomy of mathematics teachers. *Educational Studies in Mathematics*, *55*, 227-257.

Based on Vigotsky’s socio-cultural theory and constructivism, Skott (2004) outlines arguments for a move from rote memorization to one of social interaction though teacher models, and student interaction while embarking on challenging tasks. He writes about the strong link between the philosophy of mathematics and mathematics education and its history.

Skott makes an important point about the pedagogy of mathematics. He states “the intended contents of the learning experience – the concepts and procedures involved – have no individual and social development history for the student in question” (p. 236). In other words, it is not a question of which theory (drill and kill or discovery) is the best practice in teaching mathematics, but rather, how best to educate students to learn. This notion connects directly with the debate between traditionalists and reformers and the admittance of the NCTM that little research exists in the area of incorporating manipulatives and social interaction into mathematics instruction. The goal of all teachers, including myself, is to have their students increase knowledge, skills, understandings, and performance, so the means to which this goal is achieved should be studied, refined, and incorporated at its highest levels into classrooms.

Skott (2004) also outlines the challenge for mathematics teachers in achieving construction of knowledge and cognitive development among learners under the reform movement. He says it is a teacher’s responsibility,

> “to interpret the individual student’s current understandings and unobtrusively challenge them by attempting to provoke relevant mental disequilibria in order to sustain her cognitive development and procedural competence; to initiate students’ involvement in processes of for instance experimenting, investigating, generalising, and formalising and to capitalise on the resulting student conjectures and solutions when supporting their individual and communal mathematical learning; to facilitate the emergence of small communities of mathematical practice in which the contributions of individuals and groups become an accepted part of the public domain in the classroom and in which mathematically and pedagogically significant aspects of these contributions are selected and made part of the mathematical discourse. (p. 238)

Skott's (2004) description of the responsibility of a mathematics teacher, although lengthy, is pertinent to my practice and to this project. If I am to effectively deliver mathematical content, I must examine my own teaching, how it affects student development, and adjust my practice to maximize learning opportunities, whether though constructivist, social-cognitive, or pure memorization techniques.

Research Process

After conducting my review of literature I created a plan for data collection. (see Appendix A). During the course of eight weeks of school, I conducted several interventions to research the effects of increasing the use of manipulatives and social interaction during instruction. The following paragraphs describe the interventions that were implemented as well as the data collection instruments that were used.

In sixth and seventh grades, the frequency in which students manipulate objects to solve problems was increased. Before the project began, students were only supplied objects to manipulate when the textbook resources requires this action. During the implementation period, I placed objects in the learners' hands at least once every time we had class. Aside from actual objects, computer programs, virtual manipulatives, and student-made manipulatives were incorporated into instruction as well. The types of objects that supplemented instruction included fraction strips, fraction circle, fraction squares, hundreds blocks, geometric solids, rulers, color tiles, containers for volume, protractors, etc. The problems that students solved while using these manipulatives included word problems, patterns, number sense, geometric calculations, and algebraic equations. In order to most effectively distribute and collect the manipulatives, I needed to rearrange my current math supply center to make more space for the additional manipulatives that were used. I also numbered sets of manipulatives (such as the fraction strips, circles, and squares) to effectively assign materials to students and hold them accountable. On occasion, I rearranged desks to accommodate the activities in which students were engaged.

Data was collected at various points throughout the research project. Baseline data in sixth and seventh grades was collected via summative assessments (See Appendices C and F) for two weeks by requiring students to solve problems without the use of manipulatives. For the six weeks following the baseline data period, manipulatives were infused into the learning experiences in sixth and seventh grade and summative assessments were used to gauge students' knowledge, skills, and understanding. In sixth grade, student surveys (See Appendix B) were also used to gauge students' success rates, comfort levels, and confidence when problem solving, and anecdotal field notes (see Appendix D) were recorded during the problem solving process to record trends that manifested when learners were engaged in problem solving activities. In seventh grade, journal entries (see Appendix E) and interviews (See Appendix D) were conducted to investigate and record student thought processes and misconceptions as their problem solving skills were transferred to word problems.

Before the project began, students in seventh grade did not always receive the opportunity to solve a problem in context. Therefore, learners were challenged with the Important Problem of the Day (IPOD). This problem was completed towards the end of class. This intervention was meant to increase transfer of problem solving skills to problems in language context and allow students an opportunity to use the strategies they practiced when manipulating the objects during the lesson. To accomplish this intervention, students were supplied with graph paper on which to perform their calculations and imitate the process of manipulating the objects.

In eighth grade, the frequency of social interaction was increased. Although students interact socially in my classroom during activities like think-pair-share and partner work, I wanted to investigate the affects of increasing this interaction when problems solving. Therefore, during cooperative learning, I thoughtfully arranged learners in pairs and/or groups to promote social interaction. This occurred at least once a class period. While in these groups, they interacted socially with me, explaining, inquiring, and describing their findings and observations. To record this information, I used anecdotal field notes as a data collection instrument (see Appendix H). As another measure of their success, performance, confidence, and comfort level when problem solving, I administered a student survey (See Appendix I) three times over the course of the eight weeks; the first one serving as baseline data. As a culminating assessment each week and data collection method, I engaged students in a performance task that was graded on a rubric (See Appendix J).

Data Analysis

After collecting and analyzing data from this Action Research project, several recommendations for professional teaching can be made. First, incorporating manipulatives into instruction of mathematics is effective in increasing problem solving skills because students are able to visualize and manipulate otherwise abstract concepts. Furthermore, manipulatives supply teachers with several opportunities in terms of instructional delivery. They can engage students in construction of knowledge, they can model the process and have students repeat their actions, and also use manipulatives to activate prior knowledge and learning. The more that manipulatives are effectively implemented in instruction, the higher the achievement among students. Increased social interaction yields the same results. When students are able to negotiate meaning, debate, and explain their thinking to others, achievement increases as well. The most powerful learning experiences for learners are authentic tasks that engage them in cooperation and collaboration, forcing them to actively participate in meaningful learning with their peers.

1. Question 1: How does the consistent use of manipulatives affect student achievement?

The first area of investigation of this action research project was how the consistent integration of manipulatives into instruction affects academic achievement among students. Analysis of the quantitative data reveals not only an increase in use of the manipulatives to solve problems during learning experiences, but also an increase in assessment scores, especially with algebraic concepts. Qualitative data exhibits increased student confidence in their abilities to use manipulatives to solve problems, recognition and resolution of misunderstandings as well as a decrease in length of time required to solve problems.

Data source 1 – Student surveys

The first data collection instrument used to investigate the effect of consistent use of manipulatives on student achievement was a survey (See Appendix B). This survey yielded both qualitative and quantitative data. I will explain the resulting data from these surveys by supplying the quantitative data first, then the qualitative data. When the first survey was administered students were engaged in a unit of percents, and more specifically, sales, discounts, and tax. Because students did not use manipulatives, the baseline data from this survey yielded a class average score of 1.6 out of a total possible scale score of four. 76.7% of students responded “strongly disagree” when prompted about their confidence in their problem solving skills, indicating a low esteem level in this area.

Student comments reflected the low level of success during the activity. Of fifteen students, 67.7% responded negatively. Of the ten that responded negatively, 20% reported that they were confused, 30% responded that they did not like word problems and became frustrated during the process, and 50% wrote that it took too long. Scores on the second survey increased numerically and student comments reflected improvement in attitude about problem solving in general

Students were engaged in a unit on algebra in the weeks leading up to the second survey, which was given three weeks after the first. The specific learning objective the day that this survey was administered was evaluating algebraic expressions when values are given for variables. Students used color tiles and hundredths boards to visually represent the expressions and calculate the answers.

The survey exhibited a large increase in class average, mainly due to the consistent implementation of the use of manipulatives into instruction. The class average increased from the baseline average of 1.6 to 3.42 and 25% of students commented that using the manipulatives was enjoyable, and one student commented: “I had fun using the manipulatives because it helped me understand the concepts of algebra more.”

Student comments on the survey reflect increased confidence and utilization of manipulatives to solve problems. Of fifteen students 33.3% of students wrote that the manipulatives helped them. One student wrote: “I need the manipulatives because I like to visualize the problems.” Another student wrote: “I can see myself using manipulatives to solve some problems in life,” which indicates recognition on the part of this particular student that manipulatives can assist her in the future. Considering that this survey was given at the end of class, one student wrote: “I don’t think I need the manipulatives to solve algebraic expressions”.

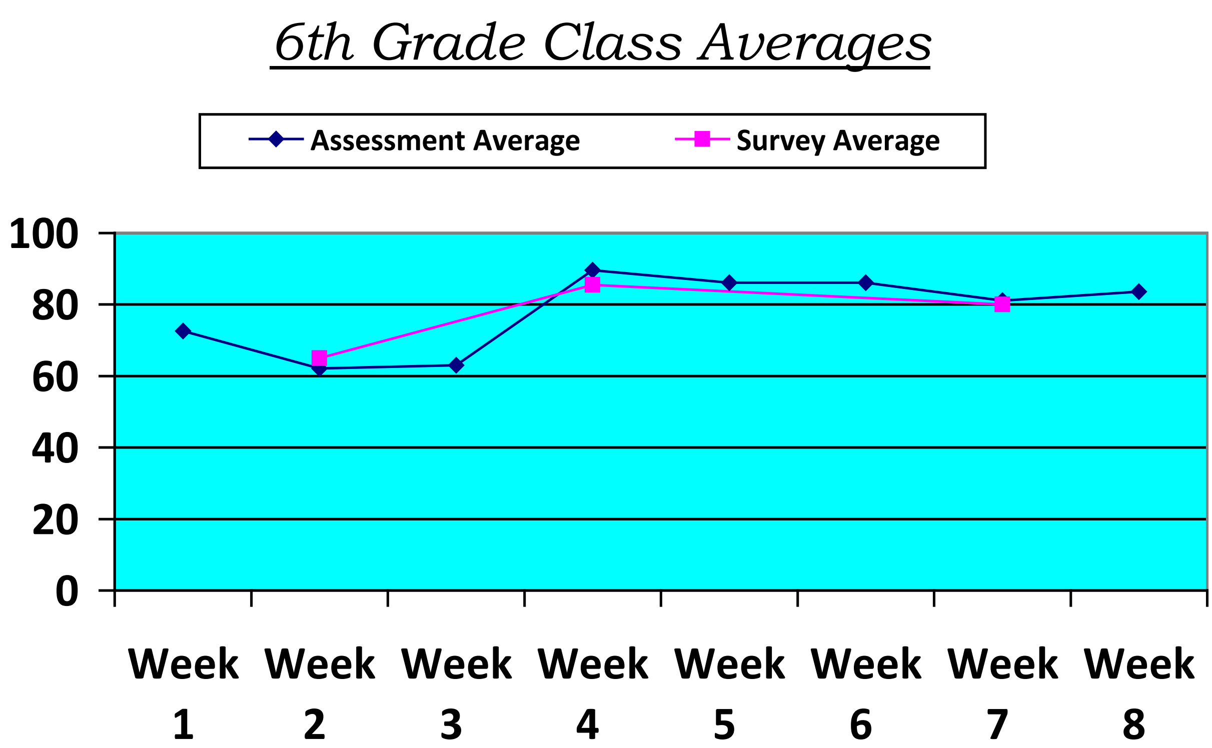
The third survey was administered during a unit on probability. On the day that the survey was administered, students calculated all possible outcomes when spinners, dice, bags of marbles, coins, and colored chips are given as a situation of possibilities. Students then tested their calculations by actually performing experiments with the materials, compared the results, developed conclusions about their findings and answered word problems based on these probability situations.

The third survey indicates that students used the manipulatives consistently; however the class average decreased in comparison to the last survey that was administered. It fell from 3.42 to 3.2. Only 15.6% of students recorded that the manipulatives helped them to understand probability, while one of these students responded "I need to work harder". Out of 16 students, 26% responded that the manipulatives helped them to visualize the possible outcomes, but still struggled with representing and calculating all possible outcomes. One student wrote that working with manipulatives and interacting with the materials actually helped him to understand the vocabulary better.

Data source 2 – Summative assessments

The second data collection instruments consisted of summative assessments (See Appendix C). Class averages over the course of the data collection process indicate a general trend of increase in success. The two baseline assessments yielded class averages of 72.6% and 62.1%. These low baseline averages were followed by another low average of 63% in the first week of implementation. However, in the following week, the class average increased dramatically to 85.1% in week 2 of implementation, then to 89.6% in week 3, exhibiting the highest performance of the eight weeks of data collection. Coinciding with this week's assessment was the second survey, which also yielded the highest score out and most positive responses from learners of the three surveys that were administered.

With the exception of the first week of implementation, the class average remained above 85% on assessments after manipulatives were incorporated into instruction. The class average on the summative assessment in week 4 of implementation was 86.1%, and in week 5 it dropped to 81.1%. In the final week of implementation, the class average rose again to 83.6%.



Data Source 3 – Anecdotal field notes

Qualitative data in the form of anecdotal field notes support trends evident in student responses to the survey and in the summative assessments (See Appendix D) Baseline data from the first two weeks of field notes exhibit frustration among students when attempting to solve problems involving discounts without manipulatives. Only 26% of students answered the question correctly, 33% of students did not finish the problem, and 13% of students withdrew from the process by putting their heads on the desk. Of those who answered incorrectly, I observed several missteps in their problem solving processes, some of which were shared by multiple students. Two students did not convert the percent into a decimal, making the amount of the discount larger than the original price. Three students failed to subtract the discount amount from the original price, and four students calculated incorrectly at some point, making their final answer incorrect. Student frustration and confusion was evident on the summative assessments during the baseline data collection period as well. The class average was the lowest in first two weeks, as many students did not earn over 60% average on these assessments.

Once implementation of manipulatives into instruction occurred, I observed a reduction in student frustration, and an increase in engagement and successful problem solving. When using mock money to investigate word problems involving discounts, 100% engagement was achieved. Although only 73.3% of students correctly represented the discount amount, the level of engagement signifies increased effort in the classroom. Although the class average only increased 0.9% from week two to week three, students exhibited more motivation to problem solve as they exerted more effort to manipulate the objects and attempt to solve the given problem.

Specific to the day that the second survey was administered, all students used the manipulatives. Successes that I observed included correct representation of the algebraic expression when a value was assigned and substituted for a variable. 73.3% of students correctly represented multiplication by developing a rectangle with the factors as length and width on their first attempt and of those students, 100% added or subtracted the remaining term in the equation. Compared to the class average score of 3.42 out of 4 (85.5%) on the survey, the success rate of 73.3 % on the first attempt is relatively close. The engagement, increased motivation, and ability to problem solve exhibited itself on the week four summative assessment as the class average jumped 22.1% from week three.

On the day of the third survey, observational records coincide with survey responses. I observed 100% engagement and participation as students worked to calculate all possible events and the probabilities of specific events. I also witnessed a variety of successes. Three students working to calculate the possible outcomes of two spinners arrived at the correct answer and were able to then compute the probability of spinning prime numbers on both spinners. One of the students in this group was the same student who commented that the manipulatives helped him to understand the vocabulary better. Some of the frustration that I witnessed stemmed not from the manipulative, but from lack of effort. Seven students over the course of activity did not develop diagrams like instructed and attempted to find all possible outcomes by adding the number of sides on the dice. If they had drawn them, they would have found that multiplication was the necessary operation.

Other probability problems were confusing to students. A group of four students required assistance after working together to try and draw a tree diagram involving the possible outcomes of spinning a spinner with four colors and rolling a numbered cube with six sides. Their misconception was apparent as they made only one tree diagram for one color, made six branches for the numbers on the cube, and then made four branches for the colors. These misunderstandings were exhibited in part on the summative assessment, as 2 students earned only a 63% average on the test. However, the class average remained above 80% indicating understanding among the majority of students.

Conclusion:

Patterns in data indicate that the implementation of the strategy of supplementing instruction with manipulatives yields positive results. Not only does quantitative data indicate an increase in academic achievement and motivation to reach learning objectives, but qualitative data indicates that learners enjoy using objects to manipulate, as they assist in the visualization of abstract concepts and help students to correct misunderstandings and mistakes. However, student responses also indicate that the use of manipulatives at this age level is more effective when concepts have been introduced and explained, rather than to construct knowledge, as many of my learners do not possess the problem-solving skills that enable effective construction. Modeling the use of manipulatives to problem solve enabled students to feel comfortable when using the materials, an impertinent component to this strategy. Motivation, enjoyment, and most importantly, academic achievement increased dramatically and remained at a consistent level after the use of manipulatives became routine during learning experiences.

Question 2: How does the use of manipulatives affect students' ability to successfully decipher which mathematical skills to use on word problems?

The second area of investigation in this actions research project was how the consistent use of manipulatives affects students' ability to decipher which operations to use when solving word problems. Qualitative data indicates that students view word problems as daunting, challenging, and boring. However, after using the manipulatives to solving these problems, students express more confidence in their problem-solving skills. Yet, quantitative data does not yield increased academic achievement, as students performed at relatively the same level during baseline collection and implementation of the strategy of the use of manipulatives into instruction.

Data Source 1 – Student Journal Entries

Qualitative data was extracted from student journal entries (See Appendix E). Baseline data indicates a lack in confidence, confusion, and frustration as students embarked on the problem-solving process. 57.4% of students recorded their indifference and dislike of word problems. Of the 19 students that wrote journal entries, only 3 expressed confidence in their problem solving skills. Two students wrote that the hate solving word problems. After students finished the baseline problems, they recorded the steps that they took to solve the problem and 36.8% of students did not write answers, 26.3% of students wrote an incorrect process, 15.7% of students recorded that they gave up, and only 21% of students wrote a process that was correct and arrived at the correct answer.

After implementation of incorporating manipulatives into instruction, student confidence increase immensely. In week one of implementation, 78.9% of students were able to correctly identify the operation necessary to solve the problem on positive and negative integers as they relate to bank accounts. After using number lines as manipulatives, 84.2% answered the question correctly, but only 73.6% of students correctly identified the operations involved, indicating that one student misunderstood the process but still arrived at the correct answer. One student commented: "the number line helped me to visualize and track the amount in each account. I was able to draw the increases and decreased in money."

The following two weeks indicated a different trend as algebra concepts were introduced. Students described their negative feelings towards word problems before the problem solving process, but described their confidence after successfully solving the problems. Over these two weeks, and average 52.6% of learners could correctly identify the operations involved to solve the problem before they attempted to solve it, and 84.2% of students could correctly identify the operations involved in the problems after using the manipulatives to solve them.

Specifically, in week three of implementation, students responded that they were confused. Although 84.2% of students responded that they did not know what operations to use, when approaching the problem, once they used color tiles to model the linear increase of cost, their responses indicated confidence and understanding of the operations involved. Of the 19 students who responded, 89.4% recorded that they answered each of the two questions correctly, and of those 17 students, 15 explained that multiplication and addition were involved in the process.

An increase in confidence and operation identification occurred in the qualitative data in week 4 of implementation. As students investigated word problems dealing with initial cost and prices thereafter, requiring application of knowledge of linear relationships, students were more successful in identifying the correct operations before and after the problem solving process. Using string and coordinate planes, students represented the increase in cost and set up equations to represent the relationship. Out of 19 students, 14 were able to identify the operations involved before using the manipulatives, and 15 were successful in applying an equation to the linear relationship.

The data from the following two weeks leveled off at approximately the same average. out of 19 students, an average of 81.5% correctly identified necessary operations when approaching word problems, with the same amount of students correctly solving the problem. Again, 78.9% of students correctly explained the process in writing.

In the final week of journal entries, more students were able to correctly identify which operations to use before solving word problems involving algebraic expressions. The average increased to 89.5% as 17 out of 19 students correctly identified which words indicated certain operations. However, 18 out of nineteen students correctly wrote equations for sentences describing algebraic expressions after using operation indicator cards to substitute word for operation signs. The same number of students was able to express the process in writing. One student commented, “the operation indicator cards helped me because although I thought I was right when I chose the operation, I was able to check my guess and make sure I was right when I looked at the card.”

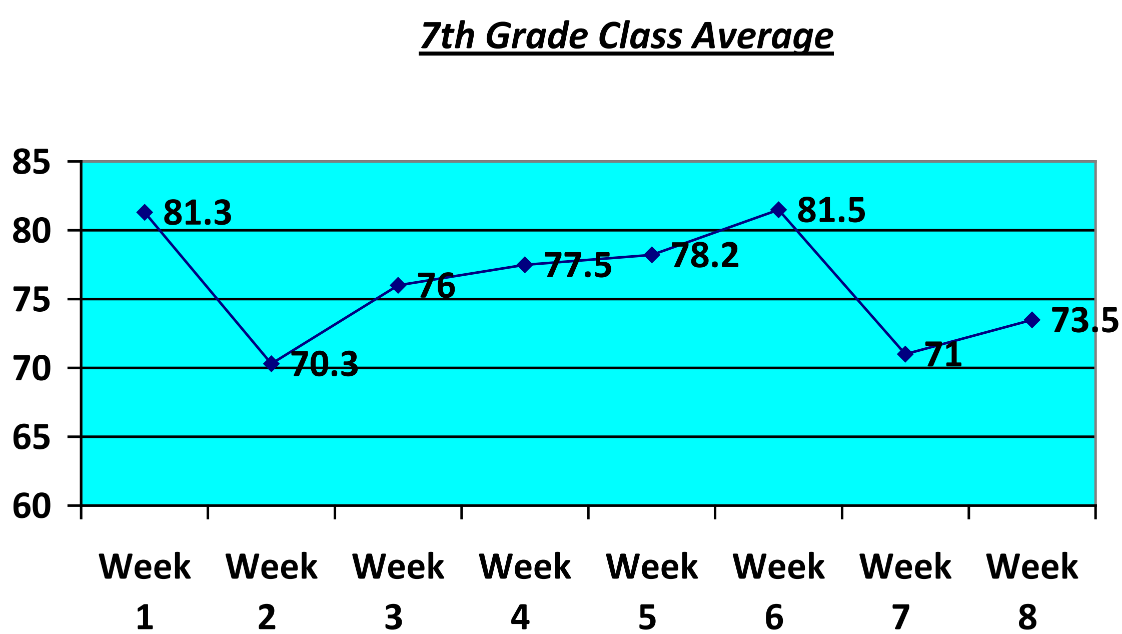
Data Source 2 – Summative Assessments

Quantitative data from summative assessments did not yield as positive a correlation as student journal entries towards the end of the implementation period (See Appendix F). Because baseline data was taken after a week of study of positive and negative numbers, students scored an average of 81.3% as a class on the first baseline data assessment, and a class average of 70.3% on the second assessment. However, the second baseline assessment included more word problems than the first, requiring more critical thinking on the part of the learner. The lower score on this assessment is reflected in student journal responses during the baseline data collection period.

In week one after implementation, the class average increased. After using number lines to investigate increases and decreases in back accounts, temperature, and heights and depths in elevation, the seventh grade class yielded an average of 76%. The most commonly missed problem on this assessment involved the difference between positive and negative temperatures. Of the 19 students that took the assessment, 15 of them answered incorrectly.

Week two of implementation also exhibited an increase in class average on the assessment, however slight. The class yielded an average of 77.5% after using scales to represent the balancing of equations. The subsequent assessment in week one of implementation yielded an increase of 6% raising the class average to 76%. This increase continued into weeks two and three of implementation, which yielded a class average of 77.5% and 78.3% respectively. The assessment from week four yielded an average of 81.5% and student confidence in journal entry responses reflected this performance, however the data last two weeks of implementation did not show the same correlation. While students answered confidently in their journals, their assessment scores decreased. In week six of intervention the class average fell to 71% and in week eight it was only 73.5%.

Figure 2



Data Source 3 – Interviews

While the data from journal responses and assessments did not coincide at times, there was a stronger correlation between qualitative data and responses from student interviews (See Appendix G). Out of the five students that were interviewed, four students consistently answered questions about the problem solving process in a manner that reflected their performance on summative assessments throughout the eight week project. Specifically, during the week when students investigated linear relationships using color tiles, Amaru was able to describe one algorithm for solving the problem by stating, “you have to start with the upfront cost, then add on the cost of each item after that until you get to the number in the problem”. He was also able to draw a sketch of how the color tiles would look when stacked to represent the situation. He received an 84.5% on the summative assessment for that week and answered every question involving initial and subsequent cost correctly.

During students’ study of solving algebraic expressions, several students were able to explain a successful method. Elexis explained the procedural method of ‘dividing on both sides of the equation because you have to keep the equation balanced, like the model you showed us,” while Amara drew a diagram that resembled the manipulatives that she used during class. Derrell verbally explained the process of solving for a variable in a two-step equation. He added, “you can check to see if you are right by plugging the number you got back into the original [equation]”. Reginald, the student that did not consistently respond with correct methods of problem solving, receives special needs accommodations. Despite his learning disability, he was able to correctly describe several methods of solving over the six week implementation period. One example was in the last week of interviews. With the operation indicator cards in front of him, he described that “eight less than a two times number is 24” would be written as $2x-8 = 24$. He was also able to solve that equation for the variable.

Conclusion

The integration of manipulatives into instruction positively affects students' abilities to problem solve. Although responses in interviews revealed the most compelling evidence of higher order thinking, students increase on individual quantitative assessments also display their increase in ability to think critically. Manipulatives assist students in visualizing the content of mathematics and help them to solve problems that can be conceptually challenging.

Question three: How does increasing social interaction among students affect student achievement in mathematics?

The third area of investigation in this action research project focused on the effect of increased social interaction on student performance. Qualitative data shows drastic increases in student confidence and comprehension of mathematical content, while quantitative data corroborates with student responses to survey questions. Learners' assessment scores increased over the period of implementation.

Data Source 1 – Anecdotal Records

During the baseline data collection period, students were not allowed to communicate when engaged in performance, or other learning tasks. Anecdotal notes were used to record their actions during this time (See Appendix H). Students were confused about how to approach the task of graphing three different situations involving the accrual of interest over a period of ten years. Common mistakes included miscalculations, inaccurate graphing, and failure to complete the assessment. Only 73% of students completed the tasks in a satisfactory nature in the first week, and only 72.6% in the second.

Once students were able to communicate about the content and their task, the number of students that were able to successfully complete the performance task and explain their thinking steadily increased. In weeks one and two of implementation, students conversed about linear relationships, and applied the slope-intercept equation to situations involving interest. One student commented, "if you can identify principal, and then you calculate the interest that will be added on each year, then you know your principle and y intercept for the graph".

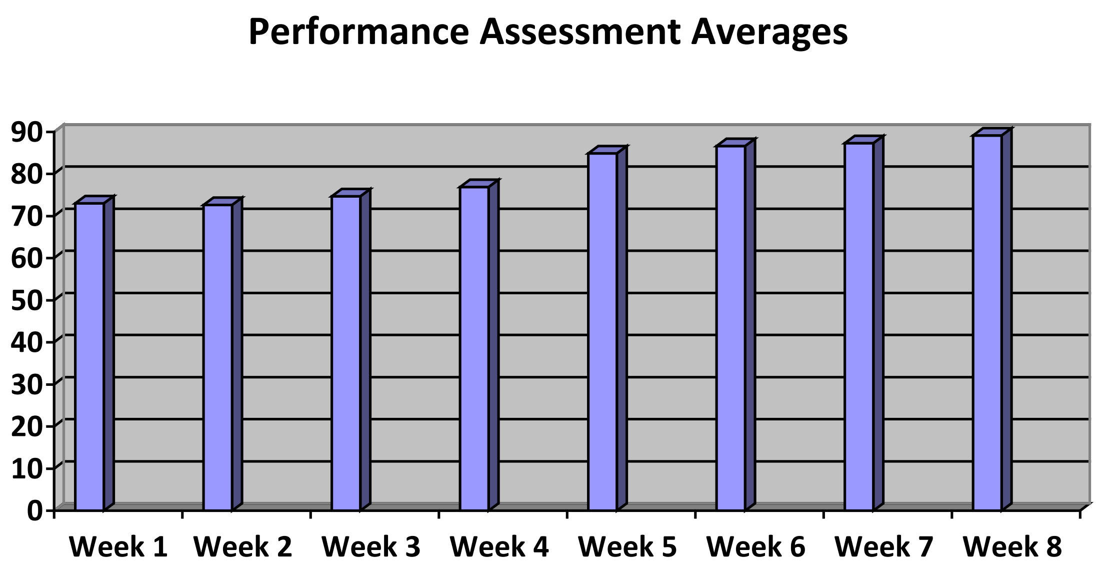
Students investigated inequalities in weeks three and four of implementation. When graphing inequalities, many debates ensued about whether to draw a solid or dotted line, and one student advised his group members to "think of it like this: if you have at least twenty dollars, you solidly have that money, so it's a solid line. If you have less than twenty, you cannot say that you solidly have it, so it is a broken like." Colleagues of this student remembered this slogan and it was repeated to remind students of how to graph inequalities. Other topics of discussion included when to switch the inequality sign when solving an inequality, and which inequality best fits real life situations.

Data Source 2 – Student Surveys

Student surveys responses coincide with anecdotal records (See Appendix I) During the first two weeks of data collection, the baseline survey yielded a Likert score of 1.32, or 33%, which is a direct result of students' inability to communicate when engaged in performance tasks. However, the second survey yielded a score of 3.2 or 80%, a drastic increase once students were allowed to communicate. The third and final survey yielded a score of 3.4, or 85%

Data Source 3 – Performance Assessments

In the baseline data collection period of two weeks, students were not allowed to communicate during their performance assessments. The class average on the performance assessment in week one was 73% and in week two it was 72.6% (See Appendix J). Once students were allowed to communicate, the average steadily increased during the remaining six weeks of the data collection period. Figure 3 displays the class average over the eight week data collection period.



Based on quantitative and qualitative data collected during the eight weeks of this project several conclusions can be made. First, the use of manipulatives to supplement instruction is effective in increasing student achievement both in computation and problem solving skills. However, the actual use of manipulatives must be modeled. Because I remained as objective and uninvolved as possible during instructional time, I did not supply feedback, and therefore learners did not benefit from teacher input. Subsequently it can be assumed that if the use of manipulatives is modeled, and feedback and guidance is supplied, student achievement would be higher than observed in this project. Social interaction proved to be effective in increasing student achievement as students worked together to solve problems, both when working with manipulatives in 6th and 7th grades, and when engaged in performance tasks in 8th grade. As students in 8th grade became accustomed to working together to solve problems, their assessment scores increased because they were learning from their peers as well as from the teacher.

Conclusion:

With all the technology that students entertain themselves with, teachers are faced with the difficult task of competing with cell phones, internet, video games, and television. In order for a task to be engaging to a learner, manipulatives and social interaction are effective means of catching learners' attention and maintaining their focus. Aside from the benefit of engagement of students, these two strategies have been proven to increase academic achievement and critical thinking skills. It is this teacher's recommendation that manipulatives and social interaction should supplement other instructional strategies at least once a week. By doing do, students have the opportunity to visualize and manipulate the content of mathematics, and discuss the process and the meaning of concepts with others engaged in the same task.

Action Plan:

The Action Research process requires dedication, effort, and time. However, its benefits are numerous to a professional teacher. Investigating important instructional strategies with children with whom the teacher has formed bonds, mentorships, and friendships is nothing short of empowering. I was empowered through this project for many reasons.

First, because I believe that each child that I teach has the capacity to learn at high levels, it is always my desire to acquire strategies that enable my learners to understand, perform, and improve at all levels. Over the eight weeks of this project, that's exactly what occurred. I gained valuable experience on how to better my assessment and instructional strategies for the benefit of my students.

Second, by engaging in this process, I was able to investigate an area of mathematics that is currently still debated by experts at every level of mathematics instruction; the use of manipulatives in instruction. Because I noticed that whenever I incorporated manipulatives into instruction, the motivation level of student increased, I wanted to investigate whether the academic achievement increased as a result. By engaging in this project, I was able to accomplish the observation necessary through both formative and summative assessments.

The action research project forced me to record anecdotal records, something that has been underused in my practice until this point. I learned the value in recording student actions, thoughts, and explanations as a way to guide my instruction. Through conducting formative assessment on a regular basis, I was able to better serve every student, from the struggling learner to the student who excels on every level. My realization of the importance of formatively assessing students will benefit my practice and my students as I use these observations in the future to push my learners to their potential and beyond.

Aside from recording formative assessment, I learned how to triangulate and analyze this data. I have always been an expert at scoring summative assessments. As a mathematics teacher, it is a natural talent. However, when combined with observational notes, this evidence of student progress becomes enlightening and empowering to the teacher. For example, in the third survey administered to the sixth grade, many students responded that they felt comfortable and confident when calculating probability, but the summative assessment a few days later yielded data that did not match their responses. Because of this discrepancy, I was able to review how the content was taught, go back several weeks later during a review session, and focus intently on the types of questions that students answered incorrectly. The summative assessment to follow contained several questions on probability and the majority of students answered correctly. This is a perfect example how this action research project underscored the importance of using assessment to inform instruction in any subject area.

Because I am switching content areas to Social Studies next year, the lessons that I have learned from this action research project will benefit my instruction immensely in the future. Since reading and writing are a major part of the social studies curriculum, formative assessment will be a necessary component to inform instruction. Unlike during formative assessment during the action research project, I will be able to conduct one-on-one conferences to provide students feedback on their essays, and correct any misunderstandings that I observe. Furthermore, by combining the data collected from qualitative data with that of quantitative assessments, I will be able to triangulate data, identify areas for reinforcement, and focus on learning gaps that learners possess.

After completing this project, I submitted my research and findings to the professional mathematics community. I shared my work with the *Education Resource Information Center*. In this endeavor I hope to share my findings with fellow teachers so they can benefit from my findings as I have learned so much from other projects like the one that I completed (See Appendix K).

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Appendix A:

Data Collection Matrix

Research Question	Data Source		
	1	2	3
1 How does the consistent use of manipulatives affect student achievement?	Student survey on their use of manipulatives	Assessments	Field notes: Anecdotal records
2 How does the use of manipulatives affect students' ability to successfully decipher which mathematical skills to use on word problems?	Journal entries	Assessments	Interviews
3 How does increasing social interaction among students affect student achievement?	Field Notes: Anecdotal Records	Student Survey: Social Interaction	Group performance tasks graded with a rubric

Appendix B

Student Survey

Name:____ Date:__________________

Student Survey: Problem Solving with Manipulatives

Directions:

Please respond to the following questions by circling the option that most closely reflects your opinion.

1. **I used the manipulatives throughout the problem solving process.**

Strongly Agree Agree Undecided Disagree Strongly Disagree

2. **The objects that I used helped me to solve the problem.**

Strongly Agree Agree Undecided Disagree Strongly Disagree

3. **I feel that I could solve the same problem without the manipulatives in front of me.**

Strongly Agree Agree Undecided Disagree Strongly Disagree

4. **I understand how to use the manipulatives to solve the problem because the teacher has explained it effectively**

Strongly Agree Agree Undecided Disagree Strongly Disagree

5. **I can explain the process of using the manipulatives to solve this problem verbally, or in writing**

Strongly Agree Agree Undecided Disagree Strongly Disagree

6. **I feel confident in my problem solving skills.**

Strongly Agree Agree Undecided Disagree Strongly Disagree

Additional comments:

Score:

SA = 5 A = 4 U = 3 D = 2 SD = 1

Appendix C

Summative Assessment for Sixth Grade

Name:____ Date:_________________

Discounts

Short Answer

1. Troy is going to basketball camp. Before he goes, he needs to buy some things. He and his parents agree that he can buy two pairs of shorts, four t-shirts, six pairs of socks, and a jacket. Shop Easy has everything they need for the following prices:

Shorts	$7.98 each
T-shirts	$6.35-on sale: buy one at the regular price, and get a second at half price
Socks	$1.98 for two pairs
Jackets	$19.99 each

   a. How much will the total bill for Troy's clothes be, including sales tax? (Figure sales tax based on what is charged in your area.)

   b. Troy had $100 when he started his shopping. Did he have enough money? If so, how much extra? If not, how much was he short?

2. Students used a computer program to test the time it took them to react to a green ball that appeared on a computer screen. Here are the reaction times for two students, a girl with initials LG and a boy with initials MC.

   LG's data values:

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
1.08 sec	0.94 sec	0.64 sec	1.00 sec	0.94 sec

   MC's data values:

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
1.25 sec	2.48 sec	1.15 sec	1.34 sec	1.47 sec

   a. Compute the difference in LG's and MC's data values for each trial.

   b. Find the sum of LG's data values.

   c. Find the sum of MC's data values.

   d. What are some statements you can make to compare the data from each for the two students?

3. Find the value of *N* that makes the number sentence true. Show your work.

   a. $2.3 + 4.09 = N$ **b.** $1.009 + 12 + 0.87 = N$ **c.** $19.81 - 12.25 = N$

d. $13.7 - 10.34 = N$ **e.** $N + 3.8 = 12.65$ **f.** $N - 2.4 = 5$

4. For each of the following problems, decide if the quotient is less than 1 or greater than 1. Explain your reasoning.

   a. $9.22 \div 2.8$ **b.** $0.9 \div 0.3$ **c.** $12.6 \div 11.8$ **d.** $5.6 \div 9.9$

5. The number of registered voters in the town of Cedarville is 8,916. In the last election, Mayor Burgis won reelection with 72% of the vote.

   a. If 52% of registered voters voted in the election, how many people voted?

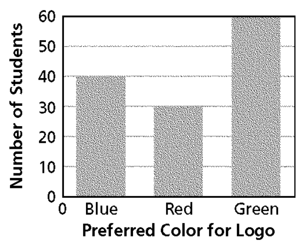
   b. Based on your answer to part (a), how many voters voted for Mayor Burgis?

   c. Based on your answers to parts (a) and (b), how many voters did not vote for Mayor Burgis?

   d. How many registered voters would need to vote in the next election for voter turnout to be 75%? Explain your reasoning.

6. Last Saturday, Aaron had lunch at a fast-food restaurant. He ordered the lunch special for \$3.29. If sales tax is 6%, how much did Aaron pay for the lunch special?

7. The student council at Metropolis Middle School conducted a survey to see whether students would prefer blue, red, or green as the new color for the school logo. The results of the survey are shown in the bar graph below.



   a. What is the total number of students who were surveyed? Explain how you found your answer.

   b. What percent of students surveyed preferred blue?

   c. What percent of students surveyed preferred red?

   d. What percent of students surveyed preferred green?

   e. If 970 students attend Metropolis Middle School, what percent of the students were surveyed? Explain how you found your answer.

8. What is 60% of 115? Explain your reasoning.

9. Paul took a trip in May. The price of gasoline that he paid during his trip was \$1.50 per gallon. He filled his van four times over the trip. The amounts he bought were: 15.082 gallons, 15.784 gallons, 14.804 gallons, and 15.331 gallons.

   a. How much gasoline did he buy on the trip?

   b. What was his total cost for gasoline on the trip?

   c. His odometer (measures distance traveled) read 23451.1 miles when he pulled out of his driveway and 24809.4 miles when he returned. How many miles did he travel on the trip?

10. Write a complete fact family for each problem.

   a. $12.4 - 3.2 = 9.2$ **b.** $3.2 \times 4.1 = 13.12$

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 11. A group of students went to the grocery store. The students spent $15.20 altogether. Each student spent $1.90. How many students were in this group?

a. 6 b. 7 c. 8 d. 9

____ 12. During gym class, Troy jumped 4.5 feet. Brendon jumped 3.72 feet. How much further did Troy jump than Brendon?

a. 1.22 ft b. 0.82 ft c. 0.78 ft d. 1.78 ft

____ 13. Which product is the smallest?

a. 0.3×0.4 b. 0.03×0.04 c. 0.3×0.004 d. 0.003×0.04

____ 14. How many decimal places are in the product of 3.76×42.89?

a. 2 b. 3 c. 4 d. 5

____ 15. How many decimal places are in the division of $3.75 \div 0.25$?

a. 0 b. 1 c. 2 d. 4

____ 16. First estimate and then find 6.234 + 7.4 + 3.67.

a. 17; 17.079 b. 10; 9.764 c. 21; 20.904 d. 17; 17.304

____ 17. Manny has $75.59 in his savings account. He takes out $12.15. How much money does he have left in the account?

a. $63.45 b. $63.44 c. $85.72 d. $87.74

Find the product.

____ 18. 0.4(0.003)

a. 0.0012 b. 0.016 c. 0.0016 d. 0.012

Use mental math to find the quotient.

____ 19. $2,386.7 \div 100$

a. 238.67 b. 2.3867 c. 238,670 d. 23.867

____ 20. Theo made the table below to show the number of middle school students who attended the last football game. If this data were displayed in a circle graph, what percent of the graph would represent the eighth graders who attended the game?

Grade	Number of Students in Attendance
6	375
7	275
8	350

a. 37.5% b. 35% c. 62.5% d. 65%

Appendix D

Anecdotal field notes template

Field notes

6^{th} Grade: Use of manipulatives

Date:______________________

Student/ Group of students: ____

Problem they are working on:

____

____

____

Successes:

____

____

____

Misconceptions:

____

____

____

Direct quotes/conversation with me or other students:

____

____

____

Appendix E

Journal Entry template for 7th grade

Name: ___________________________________ Date:________________________

Journal Entry

Directions:

1. Before you begin working on the problem given to you, complete part one.
2. When you have solved, or tried your hardest to solve the problem, complete part two.

Part One

What mathematical concepts does the problem involve?

____

____

Describe your feelings about this problem. Explain why you think you feel the way you do.

____

____

____

____

____

How will you solve the problem? Describe any processes or methods you think you will use.

____

____

____

____

Part Two

Were you successful in solving the problem?

Describe how you solved, or attempted to solve the problem. Include any methods or processes you used.

How do you feel after working to solve the problem? Explain why you think you feel this way now, after you have done the work.

Appendix F

Summative Assessment for 7th grade

Name: ____ Date:____________________

Integers in the real world

Short Answer

Solve the problem.

1. $-27 \div 3 =$

2. What value is represented by each set of chips? (B = black, R = red)
   a. 5 B, 5 R
   b. 12 B, 12 R
   c. 44 B, 44 R
   d. 113 B, 113 R
   e. What pattern do you see?

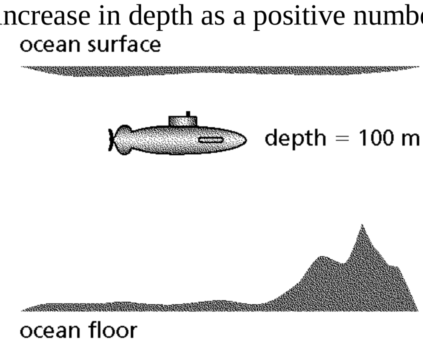
The Smarts, the Brains, the Minds, the MegaBrains, and the SoSmarts are teams that each answered five questions. The score for four of the questions and the final score are given for each team. Give the point value of the fifth question and tell whether the team answered it correctly.

3. The Minds answered a 200 point question incorrectly, a 50 point question correctly, a 100 point question incorrectly, and a 250 point question correctly. Their final score was 150 points.

Find two numbers that meet the given conditions.

4. Both numbers are greater than –15 and less than 5.
   One number is 6 greater than the other number.

Use the sketch below, which shows a submarine cruising at a depth of 100 meters. In your answer, express an increase in depth as a positive number and a decrease as a negative number.



5. The submarine is cruising at a depth of 50 meters, then dives 75 meters, then ascends (moves in the direction of the surface) 60 meters, and then dives 45 meters. What is the submarine's final depth?

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 6. Choose the symbol that makes this number statement true.

$-\frac{3}{4}\ ?\ -0.34$

a. > b. = c. <

____ 7. $-\frac{4}{5} + -1.7 =$ _______

a. -5.12 b. -2.5 c. -0.9 d. $-\frac{25}{20}$

____ 8. $520 - -264 =$ ______

a. 256 b. 344 c. 244 d. 784

____ 9. $^{-}8 \times 29 =$ _______

a. 232 b. –232 c. 211 d. –211

____ 10. $-23 \div 0.5 =$ ________

a. –11.5 b. –46 c. 11.5 d. 46

Compare. Use <, =, or >.

____ 11. $|-14|$ ■ $|10|$

a. = b. < c. >

____ 12. 7 ■ | –3 |

a. > b. = c. <

Find the sum.

____ 13. 15 + 38

a. –23 b. –53 c. 53 d. 23

Simplify the expression.

____ 14. $8 \cdot (-10) \cdot (-2)$

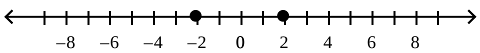
a. –4 b. 160 c. –82 d. 28

____ 15. The highest location in a certain country is 14,864 feet above sea level. The lowest point in the same country is 141 feet below sea level.

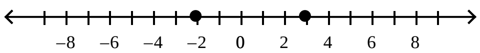
a. Find the difference of the two elevations.
b. A city is 7,642 feet above sea level. Is this elevation closer to the highest point or the lowest point?

a. 15,005 ft; lowest
b. 14,723 ft; lowest
c. 14,723 ft; highest
d. 15,005 ft; highest

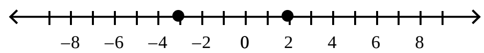
____ 16. Use a number line to find the absolute value of 2 and –2.

a.


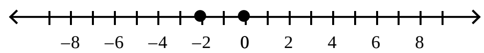
2, 2

b.


2,– 2

c.


2, 2

d.


2,– 2

Simplify the product.

____ 17. $-4 \cdot 10 \cdot 6$

a. –240 b. –241 c. –238 d. –40

Find the sum.

____ 18. 172 + (–167) + (–10) + (–144)

a. –129 b. –149 c. 185 d. 139

____ 19. Suppose you average 52 mi/h traveling on the highway. If you drive for 5 hours, how far will you travel?

a. 260 miles b. 250 miles c. 350 miles d. 240 miles

Simplify the expression.

____ 20. 6(6) + 6(4)

a. 60 b. 10 c. 16 d. 12

Appendix G

Interview Questions for 7th grade

Use of manipulatives to problem solve.

Student:____

1. What were your thoughts when you first saw this problem?

____

____

____

____

2. What operations do you think are involved in this problem? Why? How do you know?

____

____

____

____

3. How did you think you could use the manipulatives to solve the problem?   What is your plan?

____

____

____

____

4. Once you started the process of solving the problem, did you stick with your plan? How did your plan change? What, if anything did you need to change or correct?

5. Can you give me your answer? What steps did you take to get there?

6. What problem solving strategy did you use to solve this problem?

<u>Appendix H</u>

Field notes

8th Grade: Social Interaction

Date:________________________

Group of students: ____

Problem they are working on:

____

____

____

Successes:

____

____

____

Misconceptions:

____

____

____

Direct quotes/conversation other students:

____

____

____

Appendix I

Student Survey: Social Interaction

Name:______________________________________ Date:_________________________

<u>Directions</u>: Please respond to the following questions by circling the option that most closely reflects your opinion.

1. **My partner(s) and I worked together to solve the given problem.**

Strongly Agree Agree Disagree Strongly Disagree

2. **My partner helped me understand the problem with explanations, drawings, models, or mathematical computations**

Strongly Agree Agree Disagree Strongly Disagree

3. **I helped my partner(s) understand the problem with explanations, drawings, models, or mathematical computations**

Strongly Agree Agree Disagree Strongly Disagree

4. **After we solved the problem, all members of my group were able to explain the process of solving the problem to each other**

Strongly Agree Agree Disagree Strongly Disagree

5. **I better understand how to solve the problem because I worked with others**

Strongly Agree Agree Disagree Strongly Disagree

6. **I feel confident in my problem solving skills.**

Strongly Agree Agree Disagree Strongly Disagree

Additional comments:

____

____

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____

____

____

Score:

SA = 5 A = 4 D = 2 SD = 1

Appendix J

Social Interaction Rubric

	4	3	2	1
Social interaction	I communicated with my group members throughout the problem solving process by actively listening and explaining a solution to the problem	I communicated with my group members most of the time by actively listening and explaining a solution to the problem	I communicated with my group members some of the time, and was not actively involved in the problem solving process	I was not involved in the problem solving process because I did not contribute to the conversation about the problem
Problem solving	After listening to my group members' explanation of the problem, I am now able to solve the problem and explain it	I am able to solve the problem, but still have trouble communicating how to solve it.	I struggle to solve the problem and struggle to explain it	I cannot solve the problem and cannot explain it
Evidence	With my explanation, I am able to present the material visually, either with a drawing, diagram, model, or movement	I have attempted to create a visual aid, but still struggle to perfect the connection between the visual and my explanation	My visual is incomplete because I still struggle to understand the problem	I did not attempt to make a visual

Total Possible points: 12……. My Score:__________