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The Effect Of Mathematical Manipulative Materials On Third Grade Students' Participation, Engagement, And Academic Performan

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THE EFFECT OF MATHEMATICAL MANIPULATIVE MATERIALS ON THIRD GRADE STUDENTS' PARTICIPATION, ENGAGEMENT, AND ACADEMIC PERFORMANCE

by

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ABSTRACT

This study is the summary of research conducted in a third grade classroom during a unit on multi-digit addition and subtraction. The classroom teacher utilized mathematical manipulative materials throughout the course of this unit as a supplement to aid in the conceptual understanding of addition and subtraction. This study showed the effects of those manipulatives on third grade students' participation, engagement, and academic performance. Data collected from teacher observations and video recordings indicated a positive relationship between manipulatives and student participation and engagement. A pre-test/post-test and student work samples were used to determine effects on academic performance. Data showed students' academic performance increased, however the relationship between academic performance and manipulatives was found to require further research and study.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

Purpose for the Study

According to Schweinle, Meyer, and Turner (2006) the experiences that students have in the classrooms, motivationally and emotionally, are crucial factors that effect their attitudes, behaviors, and achievement. The purpose of this action research study was to examine how the use of manipulatives in my third grade classroom impacted students' experiences. A study conducted by Moch (2001) utilized manipulatives with elementary students. She found that the manipulatives allowed students an opportunity to touch and feel mathematics—not just to see it or hear it. Allowing students to be exposed to touching and feeling mathematics creates a significant change in the traditional mathematics environment. This action research study focused specifically on allowing students to manipulate math concepts in a unit on multi-digit addition and subtraction.

Rationale for the Study

The typical mathematics class in the United States is often described as one of drill and practice with little emphasis on the use of hands on manipulatives (Kutz, 1991). Research has shown that teachers spend more time and emphasis on practicing definitions and procedures and less time and emphasis on developing the technical details and rationale for those procedures (Stigler & Hiebert, 1999). Students are shown how to solve problems with no meaning of content or understanding. It has been revealed by Vinson (2001) that students in the United States possess only a moderate level of procedural knowledge and a much lower level of conceptual knowledge of mathematics. Stigler and

Hiebert believed that this reflects the cultural activity of American mathematics teaching. They have indicated that students spend the majority of their time acquiring isolated skills through repeated practice, have little time to practice problem solving procedures, and are required to learn mathematics through rote memorization and worksheets.

Teachers, despite training and professional development, have a natural tendency to teach the way that they have been taught (Quinn, 1998). In addition, elementary teachers with limited confidence in their own mathematic abilities will resort to using teaching styles based on experiences from throughout their schooling. These teachers will monopolize their time in the classroom with the traditional methods of instruction (Gresham, 2007). This involves teacher lecture, memorization, workbooks, and worksheets.

A teacher's mathematic insecurity or limited conceptual knowledge and use of teaching strategies rarely allows for the use of non-traditional teaching methods in the mathematics classroom (Gresham, 2007). These non-traditional methods include playing games, small group and individualized instruction, cooperative group work, use of manipulatives, student discussions, and explanations and justifications for their work.

State mandated testing can play a role in the type of instruction used in the classroom. The No Child Left Behind Act (NCLB) created by President Bush has increased the pressure on standardized testing scores. With a goal to close the achievement gap in the United States, NCLB has begun depriving children of meaningful educational experiences (McReynolds, 2006). The increased pressure of testing, trickles down the line of hierarchy and ultimately falls on the teachers and students. Since teachers are held accountable for their students' scores, McReynolds (2006) claimed that schools are narrowing their curriculum in order to focus more on what is tested. Therefore some teachers are teaching to the test rather than using more non-traditional methods of instruction.

During my graduate studies I have learned a great deal about the importance of enabling students to acquire conceptual understanding of mathematical procedures and concepts. I have adopted aspects of the constructivist approach and believe that learning should be student centered. In my own experiences as a student I struggled in classrooms that used traditional instructional routines. These classrooms utilized a sit and listen approach in which I was required to listen to a teacher lecture and tell how to solve a problem. In my experience as a teacher, I have encountered students that come into my classroom ready for me to tell them how to solve the problems.

I want to provide my students with the greatest opportunity for a quality education. NCTM (2000) claims that if mathematics becomes a process of copying and memorizing student interest is likely to deteriorate, however, if learning is appealing and understandable students will remain engaged. It was a blend of the above research and my personal goals to become a better teacher that led me to investigate the practice of using manipulatives in my third grade classroom. My goal was to study what, if any, impact manipulatives had on student engagement, participation in class, and academic performance.

Research Questions

My action research was designed to answer two specific research questions:

Question #1

What effect do mathematical manipulatives have on my third grade students' engagement and participation?

Question #2

What effect do mathematical manipulatives have on my third grade students' academic performance in multi-digit addition and subtraction?

Definitions:

Terminology pertinent to this research study was defined as follows:

Academic Performance: determines whether learning is occurring. Indicators of growth in academic performance include but are not limited to: changes in students' pre-test and post-test scores and records of work used to solve problems.

Conceptual Understanding: students' comprehension of the meaning of mathematical concepts and procedures.

Constructivism: is based on the idea that learners build knowledge based on personal experiences and beliefs. Constructivist learning experiences include explorations, interactive group work, engaging discussions, and student-centered activities (Snider & Roehl, 2007).

Engagement: refers to active, goal-directed, flexible, constructive, persistent, focused interactions with the social and physical environment (Furrer and Skinner, 2003).

Direct Instruction: a model for teaching that is teacher centered and mostly incorporates teacher lecture as the method for teaching students. The teacher tells the students how and when to apply a new strategy (Kroesbergem, Van Luit, & Maas, 2004). This is a commonly used type of instruction in traditional teaching.

Guided Instruction: a model for teaching that is student centered and mostly incorporates explorations, group work, and engaging discussions as the method for teaching students. The lesson and class discussion centers on students' contributions and strategies (Kroesbergem, Van Luit, & Maas, 2004). This is a commonly used type of instruction in constructivism.

Mathematical Manipulative Materials: materials that represent explicitly and concretely mathematical ideas that are abstract. They have visual and tactile appeal and can be manipulated by students through hands-on experiences (Moyer, 2001). These include but are not limited to counters, snap cubes, base-ten blocks, pattern blocks, color tiles, dice, geoboards, tangrams, hundreds board, cuisenaire rods, and cm cubes. Common household items can also serve as manipulative materials, such as: beans, coins, scales, toothpicks, and checkers.

Mathematic Tools: It should be distinguished that there are also mathematical tools that can be utilized, however do not qualify as manipulative materials. These tools include items such as: rulers, measuring tapes, calculators, and protractors.

Participation: an active involvement in classroom activities: asking questions, offering examples, and contributions in class discussions.

Procedural Understanding: understanding that relates to the steps used to solve math problems.

Standard Algorithm: the commonly used step-by-step procedure for solving a problem, which is memorized.

Traditional Teaching: refers to teacher centered teaching in which directed guided practice, independent practice, continuous assessment, and application of learned skills are used. The teacher is seen as the conveyor of knowledge and the students are expected to learn mostly through teacher lecture.

Significance of the Study

The National Council of Mathematics claims that learning in grades three through five should cultivate more than the students' abilities to make sense of mathematics; it should enhance their ability to solve problems (NCTM, 2000). Students need to understand the mathematical concepts presented to them in order to have the ability to build on those concepts. Teaching through isolated skills may not be the best method for students to conceptually understand mathematics. Egendoerfer's (2006) findings indicated that the memorization of facts without understanding underlying concepts makes it increasingly difficult for students to acquire new mathematical skills. In order to promote the conceptualization and understanding, information should be presented to students in a manner that allows them to create their own understanding of "why" this math works the way it does, rather than being told to memorize a formula. Madrazo and Motz (2005) declared that lecture continues to be the most widely used method in the classroom. Through their research they claimed that countless studies indicated students retained the most information by teaching others, practicing by doing, and discussing in groups. Students need to be given the opportunity to touch, manipulate, and construct their own meaning and understanding. This can be achieved through the use of manipulative materials. According to Ross and Kurtz (1993), the proper use of mathematical manipulative materials can support the student's conceptualization and understanding. This study made use of manipulative materials, specifically within a mathematics unit on multi-digit addition and subtraction.

Summary

Through an extensive review of literature many relevant ideas were revealed. The type of instruction in the classroom plays an important role on the methods and materials used to teach some mathematical content, and therefore I will further discuss traditional and constructivist styles of instruction. Also in the following chapter I will address the proper use of mathematical manipulatives and the importance of the teachers' conceptual knowledge of these materials. In addition, information on student engagement and participation will be shared, number operations and concepts involving multi-digit addition and subtraction, and student academic performance in relation to the aforementioned. Subsequent chapters will include the methodology of this study, data analysis, and conclusions made based on the data.

CHAPTER TWO: LITERATURE REVIEW

Introduction

Understanding where we are is essential for establishing where we want to go. The purpose of this literature review was to explore the traditional instructional methods, the trend toward alternative instructional methods, the role of participation in the classrooms, the use of manipulative materials in the mathematics class, and the effects of manipulatives on student learning.

Traditional teaching methods

Traditional teaching methods mainly incorporate instruction centered on the teacher in which directed guided practice, independent practice, continuous assessment, and application of learned skills are used. Traditionally, the rote memorization approach is used most often. Students are shown how to perform the specific task and are asked to memorize it. The focus of this type of lesson is on memorizing and using standard algorithms, after which students typically complete practice worksheets and timed drills. Procedures for problem solving are the main focus.

The National Council of Teachers of Mathematics (NCTM) strongly encourages teaching mathematical understanding and reasoning. Unfortunately, many classroom teachers do not teach for understanding and reasoning. They spend most of their mathematical time learning and practicing computation procedures. Teachers spend much time using more traditional teaching methods, such as lecture, directed guided practice, independent practice, rote memorization, worksheets, and the use of standard algorithms only (Gresham, 2007). Teachers concentrate more on basic skills rather than concepts and devote more time to seatwork and whole class instruction. Teaching the textbook problem by problem and insisting on only one correct way to complete a problem prevents mathematic development (Baroody, 2006). A quality mathematics experience should involve much more than these traditional approaches.

Alsup and Sprigler (2003) investigated the impact the traditional method of instruction had on the student achievement of 335 eighth graders. The researchers compared a direct instruction curriculum with a reform curriculum that utilized hands-on and laboratory activities. SAT scores were recorded for all of the students who attended the researcher's class during the course of three school years. During the first year the students were taught using the direct instruction curriculum, the second year was taught using the reform curriculum, and the final year used a combination of both types of instruction. The study resulted in no significant improvement in achievement among the students receiving the reformed instruction; however the students in the traditional classroom setting demonstrated improvement on procedural tasks.

Baroody (2006) studied how children learn and master mathematics and discussed the conventional method of instruction. According to Baroody conventional instruction makes learning basic mathematics difficult, and when the focus is on memorizing individual combinations children are robbed of mathematical proficiency. This way of teaching is purely procedural. Students are given quick facts and are forced to memorize them. There is no meaning behind it. When this is done, Baroody says the students are more likely to misapply this information. It is likely that the students do not truly understand the meaning behind the memorized facts. In addition, Sousa (1995) claims that lecture results in the lowest degree of retention. Even if students are able to gain understanding of the concepts they are more likely to forget it quickly.

Issacs and Carroll (1999) worked with elementary school students to teach basic number facts. Their work implicated that the traditional rote approach to teaching basic facts, including the use of drills and timed tests, could create severe weaknesses in student understanding. This way of teaching involves force feeding the students facts and requiring that they are able to regurgitate these facts quickly.

Cain-Caston (1996) designed a study to compare the mathematics achievement of third grade students who were taught using manipulatives and third grade students who were taught using worksheets. Student achievement of the 70 third graders in four classrooms was assessed using the California Achievement Test Form E. As a result of the study, Cain Caston believed that the practice of using worksheets discouraged students from thinking about or solving mathematical problems for themselves and simply required them to recite a previously memorized fact or theory. For the student, there is no meaning or understanding behind the facts and in turn will make more advanced problems more difficult for them.

Kroesbergem, Van Luit, and Maas (2004) questioned the benefits of using traditional explicit teaching versus constructivist instruction with students identified with a learning disability. Their study compared three sets of conditions: traditional explicit instruction, constructivist instruction, and a control group based on the regular curriculum. These conditions were meant to identify any benefits on student fact automaticity and problem solving. The participants included students from elementary schools for general education and elementary schools for special education. Students were selected to participate based on low math performance. The study concluded both explicit and constructivist instruction were effective compared to the regular curriculum in automaticity and problem solving, and students who received explicit instruction did not differ from students receiving constructivist instruction in terms of automaticity. Low achieving students participating in the explicit instruction classroom did however demonstrate greater improvement in problem solving than their counterparts. These results support assumptions that students with learning difficulties, when compared to normally achieving students, can benefit more from instruction that utilizes the explicit teaching of mathematics strategies (Kroesbergem, Van Luit, & Maas, 2004).

Constructivism

Constructivism is based on the idea that learners build knowledge based on personal experiences and beliefs. It is not enough for students to know the rules and memorize the algorithms for solving problems. They need to know the reason behind the rules and algorithms. Teaching to the textbook with a stand and deliver technique is not the only way to approach instruction in a mathematics classroom. Good performance in mathematics calls for more than the acquisition of the procedural computational skills (De Corte, 1995). As more research on student learning is done and shared with educators, new approaches to teaching the basic mathematics facts are being implemented. Isaacs and Carroll (1999) deem an appropriate approach to begin with the children’s natural thinking.

In order to push students toward thinking on their own, students may be given a problem without any prior direct instruction on the concept. Students would then be encouraged to share their strategies for solving the problem with the class. This approach can result in a variety of problem solving strategies for one problem. Students are made aware that there may be more than one way to find a solution to a problem, despite possible previous math experiences and established perceptions about math. Students are forced to attempt to make meaning of each of the varied strategies presented by their classmates. Understanding the different strategies may allow a student to continue use of their own strategy or to choose to adopt an alternative strategy for their use in the future. In this sort of situation the students are being required to think conceptually about the math material and understand why it "works" in the many different ways.

Baroody (2006) studied instructional methods that affect the way elementary students learn basic number computations. In addition to the conventional view, Baroody studied the number-sense view that emphasized conceptual understanding. Number combinations should be learned and practiced in a purposeful manner (Baroody, 2006). Purposeful learning allows students to discover their own patterns and strategies. This permits students to gain a greater conceptual understanding.

Allowing students the opportunity to think for themselves rather than the teachers and textbooks doing the thinking for them requires students to become responsible for finding their own methods of solving a problem. This is a method that Carpenter, Franke, Jacobs, Fennema, and Empson (1997) discussed in their study of invention and student understanding in regards to multi-digit addition and subtraction. Carpenter et.al. (1997) studied 82 student's progression of these math concepts through their years in grades one through three. Their goal was to identify if there existed a difference in understanding among students who used invented strategies to solve problems before they learned standard algorithms and students who learned the algorithms prior to constructing their own invented strategies. No guidelines on instructional methods were given to the teachers involved in the study. Many teachers allowed students the opportunity to solve problems with the use of varied strategies. The student strategies and alternative strategies were often shared and discussed with the whole class. Carpenter et.al. found that by the end of the three years of school most students were using the standard algorithms more than the invented strategy. The researchers were not surprised to find the largest jump in the use of standard addition and subtraction algorithms came between the grade 2 fall and spring interviews, when the standard algorithms were introduced in most classes. Despite the jump in the use of algorithms a discovery was made about the students who utilized invention strategies prior to learning the standard algorithms. Carpenter et al. stated that:

> Students who initially used invented procedures demonstrated knowledge of base-ten concepts before students who relied primarily on algorithms. Second, invented strategies demonstrate a hallmark characteristic of understanding. Children who use them are able to use them flexibly to transfer their use to new situations as demonstrated by the fact that students in the invented-strategy groups were significantly more successful in solving the extension problems than students in the algorithm group. Finally, students in the invented-strategy group demonstrated significantly fewer systematic errors than students in the algorithm group. (p. 16)

It is clear that many benefits were found with the students who invented strategies for problem solving before learning the standard procedure with understanding. Allowing the students to create their own meaning and method for working a problem allows for a greater understanding of the math concept than simply telling the student how the problem should be solved.

Hiebert and Wearne (1996) studied the influence of instruction on children's understanding of multidigit numbers and computational skills. The researchers followed 70 children over the course of their first three years of school. Students received either textbook instruction or an alternative instruction using manipulatives and student discussion. Based on their results, Hiebert and Wearne have recommended that instruction should be based on supporting student understanding in place of developing procedural proficiency. They researched alternative and conventional instruction and the impact of the type of instruction on conceptual understanding and skill. The alternative instruction allowed students to construct relations of different kinds and to develop their own procedures and explanations to problem solving. The conventional approach devoted more time to textbook driven instruction. Lessons were taught by demonstrating how to solve a problem and assigning students additional practice of similar problems. Students worked independently and were encouraged to use standard algorithms. The students in the conventional classroom were able to perform at higher levels; however they were less able to demonstrate higher levels of understanding. Hiebert and Wearne discovered the alternative instruction facilitated higher levels of both understanding and skill in students. Therefore it is important for teachers to possess a firm conceptual understanding of mathematics.

Research done by Kamii, Rummelsburg, and Kari (2005) investigated the practice of using traditional instruction and constructivist instruction to teach arithmetic to low performing and low-SES first graders. Throughout the course of a school year, one group of students were taught arithmetic through traditional methods while another group of students were taught by an instructor who utilized constructivist strategies that emphasized physical-knowledge activities. It was discovered that the students in the latter group performed overwhelmingly better than the traditional students. The constructivist group was able to perform at a higher level of logico-mathematical thinking and therefore had a more solid mathematical foundation and was more capable of remembering numerical facts (Kamii, Rummelsburg, & Kari, 2005). The work of McCaffrey, Hamilton, Stecher, Klein, Bugliari, and Robyn (2001) harmonized closely with the aforementioned study. The researchers explored the effects of instructional practices in a high school classroom. It was found that students receiving instruction utilizing reform based methods (student-centered, inquiry based, manipulatives, and class discussions) were able to perform higher than the students who did not receive this type of instruction (McCaffrey, et al., 2001).

Participation and Engagement

“I hear and I forget, I see and I remember, I do and I understand.” This old Chinese proverb mirrors much of the research on student participation. Participation is an active involvement in classroom activities, which includes answering questions (volunteering and being called on), sharing ideas and thoughts, sharing strategies at the board, talking with classmates or the teacher about the problem, and completing written work. Research shows learning is an active process in which students learn best when they actively participate in the learning process (Petress, 2006). He has indicated that an integral part of the learning process is student participation in classroom activities and discussions. He found that students are capable of generalizing what they have learned from a classroom learning activity more so than from listening, watching, or reading about it. In addition students have shown greater retention when they have been introduced to new concepts by using manipulatives. In order for students to obtain the maximum benefits of learning by active involvement, true participation and engagement are essential (Petress, 2006).

Turner and Patrick (2004) studied teacher and student interactions in a classroom to determine the effects of participation on student understanding. The focus of their study was on two students in mathematics class during sixth and seventh grade. These students were given multiple math specific surveys. In order to determine the individual students' participation, the researchers identified all of the occurrences of student talk or behavior, and teacher talk or behavior directed at that student. They found that participation in classroom learning activities provided students with opportunities to learn and practice new knowledge and strategies. They also discovered this practice allowed students to explain their reasoning and to examine their thinking processes. Further, Turner and Patrick indicated that immersed participation, as described, encouraged students to think, understand, examine, strategize, practice, and solve problems for themselves.

Skinner and Belmont (1993) conducted a study that observed teacher behaviors and student engagement. Their study showed that students involved in learning activities had a more positive attitude and were more engaged when sustained over time. Skinner, Wellborn, and Connell (1990) also found that when students were more engaged in academics they earned higher grades and had a tendency to score higher on state standardized tests.

Turner and Patrick (2004) concluded that the classroom environment must be conducive for participation. Participating in learning activities involves a certain amount of risk for the students. Student sharing of personal thoughts and ideas among classmates and the teacher can bring about rejection and the fear of getting the wrong answer or not making sense. However, teacher discourse and classroom social norms will either inhibit or motivate students to participate and/or become actively engaged in the learning process. Turner and Patrick have shown students would be most willing to participate in classrooms when teachers expressed enthusiasm about learning, communicated a belief that all students can learn, and provided academic and emotional support for students' understanding. Teachers have the ability to create an environment that can enable or disable students' motivation to participate. The types of instructional practices, coupled with teacher enthusiasm and teacher support of students, can facilitate an environment favorable for active student participation and engagement. Using manipulative materials as part of instruction can help to increase this favorable classroom environment. These materials can serve as a means of motivation. Marzola (1987) studied the use of manipulatives in math instruction. The research collected shows that the appropriate use of manipulative materials can result in an increase of on-task behavior and student awareness.

Benefits of Mathematic Manipulative Materials

Nevin (1993) declared that our goal in teaching mathematics is to have students understand and apply mathematics to the everyday world. Student understanding can only come when they have been actively involved in their own learning- students must *do* mathematics. They need to take charge of their own learning and teachers must show them how and provide them with the opportunities to do so. O'Shea (1993) supports the idea that manipulatives can help teachers and students to bridge the gap that divides how mathematics is taught and how mathematics is learned. According to Balka (1993), manipulative use in the classroom can help students at all grade levels to understand processes, communicate their mathematical thinking, and extend their mathematical ideas to higher cognitive levels.

Moch (2001) believes that using manipulative materials in the classroom in order to promote learning is a best-practice technique. Piaget (1952) has suggested that children do not possess the mental maturity that is required to understand abstract mathematical concepts that are presented to them only in words and symbols. He also suggests that students need numerous experiences with concrete materials and drawings for the learning of these concepts to occur. Manipulative materials are designed to be concrete representations of abstract ideas and are to be manipulated, precisely as their name implies. Moyer (2001) studied 10 teachers, focusing on how and why they used manipulative materials in their classrooms. While the teachers who participated in the study claimed that the manipulative materials were fun but not necessary to teaching and learning mathematical concepts, there was an overwhelming positive behavior exhibited by students when using the manipulative materials. Moyer found that in lessons where manipulatives were used students appeared to be interested, active, and involved. Sowell (1989) used a meta-analysis of 60 different studies to help determine the effects of using manipulative materials on students' achievements and attitudes in mathematics instruction. She found that over a longer period of time, a school year, elementary students who used manipulative materials had greater achievement, retention, transfer, and attitudes in mathematics class.

In her analysis of 64 research studies, Suydam (1986) reported that there was a considerable difference in students who had used manipulatives and those who did not. Students who had been given the opportunity to use manipulatives scored in the 85^{th} percentile on achievement tests, while those who did not scored in the 50^{th} percentile on achievement tests. She found that lessons using manipulative materials had a greater chance of producing greater mathematics achievement than lessons in which such materials were not used.

Children are naturally curious, playful, and full of energy. Children do not often enjoy sitting for extended periods of time and listening to their teacher lecture. Beyond the lack of enjoyment, most students in a sit and listen math lesson walk away with a low degree of understanding and retention (Sousa, 1995). Utilizing manipulative materials allows children to break away from the traditional classroom setting and instructional style. Using manipulative materials can be exciting and motivating to students, naturally leading toward a greater interest in the intended use of the manipulatives and the learning activity.

Ross and Kurtz (1993) followed a second grade teacher throughout a lesson on adding multiple numbers. This teacher had students playing a game that used base-ten blocks. The game required that the students alternate turns rolling two number cubes and cumulatively add the sum rolled to the number they obtained in their previous turn. Rolls continued alternating between students. The goal was to be the first player to acquire 100. Students used base-ten blocks to keep track of their totals and were actively engaged and participating in the game. Throughout the course of the game students began making their own discoveries: finding how many more they need to get to 100 (two digit subtraction), finding that they could trade their ten one's for one ten (regrouping), and counting by tens rather than ones (mastering more efficient ways to count). The students were given time on their own to make their own discoveries. These discoveries and strategies had personal meaning because they were discovered on their own rather than being told to them. Ross and Kurtz (1993) reported that the second grade teacher found the amount of time spent reteaching and remediating was greatly reduced as a result of allowing his students the time to build and reflect on their own personal knowledge. In addition, the research showed that the effective use of manipulatives contributed to student conceptualization and understanding.

A study by Englert and Sinicrope (1994) corroborates Ross and Kurtz's (1993) research. Englert and Sinicrope studied two-digit multiplication using manipulatives to make a connection to the standard algorithm. The teachers in this study found similar results. Teaching using manipulatives required a great deal of time at the beginning in order to develop the students understanding of the multiplication algorithm, however the students required less time for review and re-teaching when compared to a more traditional approach. The multiplication was meaningful to the students, and therefore they had a much deeper and more permanent understanding (Englert and Sinicrope, 1994).

Proper Use of Manipulatives

Using appropriate concrete instructional materials in the classroom is a way to ensure that the students understand the mathematical concepts presented (Vinson, 2001). While a kinesthetic experience can enhance perception, thinking, and conceptual understanding, Ball (1992) stated that understanding does not travel through the fingertips and up the arm. Ball expressed concern that teachers view manipulatives as a magical band-aid that will heal all the problems that students have in acquiring mathematical understanding. This is not the case.

Manipulatives need to be introduced and used properly in order for them to work. According to Sanders (1993), manipulatives must be selected that support the goals of teaching. It is not appropriate for fraction circles to be used when students are learning multiplication of whole numbers. In addition, simply giving the students the materials and allowing them to play with them will not ensure that learning is taking place. Teachers need to develop and oversee lessons utilizing manipulatives. Students need to be given the opportunity to discuss and share techniques and strategies related to manipulative use. If there is no discourse between the teacher and students, the children are simply following rote procedures for the use of the materials. It is entirely possible to utilize manipulative materials and continue teaching with traditional procedures. Teachers need to facilitate appropriate discourse that emphasizes the conceptual understanding demonstrated by the manipulative materials.

Many teachers grew up and learned mathematics themselves through the rote memorization routines (Trueblood, 1986). Ball (1992) claimed that a number of teachers are competent with procedures, however many have not had the opportunity to develop the accompanying conceptual understandings that are crucial to managing the development of appropriate concrete contexts for learning mathematics. In addition it is increasingly difficult for these teachers to respond to students' discoveries without the conceptual understanding to reinforce them. In order for manipulatives to be used to their maximum potential, they must be utilized properly. Teachers using manipulative materials in their classrooms need to possess a deep conceptual understanding and have the ability to pass that along to their students. Allowing more opportunities for talking and mathematical discussions and allowing students to share their thinking can help accomplish this.

In addition to conceptual understanding, there is a certain comfort level teachers should have with manipulatives in order to use them properly. Chung (2004) claimed that teachers who are not comfortable with the use of manipulative materials are likely to decrease the effectiveness of instruction, classroom management, and student achievement. Teachers who are trained to use and understand manipulatives properly may be able to override their natural tendency to teach the way that they were taught (Quinn, 1998).

By demonstrating how to use the manipulatives as tools for better understanding, teacher's open doors for many students who struggle with abstract symbols. Moyer and Jones (2004) claimed that struggles could be minimized or eliminated by using different representations before using abstract symbols alone. This gives the students a firm conceptual base on which to build higher mathematical thinking.

Student sharing and explaining to their classmates is essential for optimal use of manipulatives. It is, however, a critical component of the use of manipulatives that students also be able to build a connection between the representational mathematical concepts that they have discovered through the use of the manipulatives and the procedural knowledge that the manipulatives are supposed to support (NCTM, 1989). Nevin (1993) believes that students need to record their actions with the manipulatives in order to see the connection and to arrive at their conclusions. This can include, but is not limited to using symbols. Students can write to show the actions they used. This record is a tremendous aid for teachers to monitor student understanding.

Bohan and Shawaker (1994) studied connections of conceptual knowledge using manipulatives and the procedural knowledge they promote. If manipulatives are utilized to bridge the two types of knowledge, then they can be an essential and enlightening component of the mathematics experience (Bohan and Shawaker, 1994). The manipulatives are not meant to be the quick fix or an exclusive method in solving math problems; however they are to be used as a building block to provide students with the conceptual understanding of math content with the goal of enabling them to find their own, more efficient strategies for solving problems.

Summary

The significance of teaching mathematical concepts utilizing hands on manipulative materials has been discussed. The review of literature and research that has been presented provides evidence of the importance of the participation and engagement of students and their understanding of mathematic concepts. The following chapters will discuss the methodology used to conduct research examining the third graders use of manipulative materials, analysis of the data collected, the conclusions derived from the study, and recommendations for future research.

CHAPTER THREE: METHODOLOGY

Introduction

As a classroom teacher, I am interested in enhancing my students' mathematical academic performance, as well as their engagement and participation in mathematics. I conducted this study to determine the effects of using mathematical manipulative materials on student participation and engagement, as well as academic performance. The purpose of this study was to reflect on my own teaching practices in using these manipulatives and how they impacted my students' classroom participation and performance. My questions, "What effect do mathematical manipulatives have on third grade students' engagement and participation?" and "What effect do mathematical manipulatives have on third grade students' academic performance in multi-digit addition and subtraction?" needed to be explored in the third grade classroom. In this chapter I describe the setting of the research and the methods used to acquire the appropriate information in order to answer the research questions.

Design of the Study

According to Johnson (2008) action research is a planned, methodical observation related to one's teaching. Both quantitative and qualitative data collection methods were used in this study. This action research study collected data on student engagement, participation, and academic performance through the use student work samples, video recordings, teacher field notes, and a pre-test and post-test.

Setting

School Setting

This study took place in an elementary school in the suburban area of Central Florida. The elementary school provided for students in pre-kindergarten to fifth grade. The school is a Title 1 school and received federal dollars for the education of the students. The school also received IDEA funds and Reading First grants. This elementary school is a bilingual center. According to 2007 demographics the student body population is 22% White- Non Hispanic, 9% Black, 65% Hispanic, and 4% Other. Five different languages are spoken in the homes of students attending this school and 21% of the students are served by the exceptional education programs (Specific Learning Disabilities (SLD), Educable Mentally Handicapped (EMH), Emotionally Handicapped (EH), Gifted, Speech and Language, Autistic, Other Health Impaired, Developmentally Delayed and Trainable Mentally Handicapped (TMH)). Nearly 47% of the students served in the basic classrooms are instructed with ESOL strategies. Approximately 77% of the students are enrolled in the Free and Reduced Lunch Program offered by the school district. The school has a 58% mobility rate.

Classroom Setting

This study was conducted in a basic third grade classroom consisting of 22 students ranging in age from 8 to 10 years old. The school principal created all the third grade classes on the basis of establishing a diverse range of gender, race, and reading and math ability level. Mathematics, reading, language, science, and social studies were taught to the same group of students throughout each day in the same classroom. The mathematics instruction began following the special area time at the beginning of the day, 9:45 am, and lasted for about one hour every day.

Of the 22 students in the class one received exceptional education services and did not participate in the math class involved in the study. One student was autistic and was mainstreamed into this class for mathematics instruction. One student received gifted services and four students were classified as ESOL and received the appropriate accommodations. All students returned the parental consent and signed the student assent form; however, two students were not permitted to be video recorded. Data on those two students were limited to work samples, teacher observations and field notes, and pre-test and post-test. The students participating in video recording consisted of 11 male and 8 female. The students participating in all other aspects of data collection were 11 male and 10 female. The research group was comprised of 6 White, 1 Black, 2 Asian, 11 Hispanic, and 1 mixed student. As a part of general classroom procedures, students were assigned numbers for use in the classroom throughout the school year. For the purpose of this research, the above students will be identified by their previously assigned number as shown below in Table 1.

Table 1: Student assigned numbers, gender, and race

Student #	Gender	Race
1	M	Hispanic
2	F	Asian
3	F	Hispanic
4	F	Asian
5	F	White
6	F	Hispanic
7	M	Hispanic
8	M	White
9	M	Hispanic
10	F	Hispanic
11	F	Hispanic
12	M	White
13	M	Hispanic
14	Non-participant in Study	
15	M	MIXED
16	M	White
17	F	Hispanic
18	M	White
19	F	Black
20	M	White
21	F	Hispanic
22	M	Hispanic

Data Collection

Before the start of this study permission was requested and obtained by the University of Central Florida Institutional Review Board (IRB) (Appendix A). Approval was obtained from the school principal (Appendix B) and parental consent forms (Appendix C) were sent home. Parental consent forms were returned with the required signatures, granting permission for each student to participate in the study. In addition, the student assent letter (Appendix D) was read aloud to all students, a brief explanation of the project was given, and the opportunity to ask questions was permitted. The study began after all permission sources were attained.

Instruments

Data were collected through a variety of different instruments. Johnson (2008) suggested the use of two to four types of data in order to keep research focused. These data sources included: teacher field notes based on classroom observations, a teacher made identical pre-test and post-test, selected video recordings of math lessons, and student work samples. These sources allowed observance of any possible changes or progress in the students understanding of the mathematical content. In addition, the sources afforded the opportunity to observe and note the interactions and behaviors among the students, specifically when manipulative materials were involved in the lessons. All of the data collected were kept confidential and locked in a secure location when not in use. Detailed instrument description will follow in the data analysis section.

Procedures

At the start of the study, a discussion was held with the students regarding what participation meant to them and what it looked like in the classroom setting. During the course of the study I sequentially followed the order of instruction presented in the assigned textbook. This order of instruction can be found in Table 2.

Table 2: Sequence of Mathematical Content Addressed During the Study

Sequence of Instruction of Mathematic Content	**Number of Days Spent on Content**	**Approximate Time per Day Spent Teaching Content**
Fact and Number Families- review of relationship between addition and subtraction	1 day	60 minutes
Extensions of Addition and Subtraction facts	1 day	60 minutes
Introduction to candy shop	3 days	60 minutes
Addition with regrouping – 2 digit numbers	2 days	60 minutes
Addition with regrouping – 3 digit numbers	1.5 days	60 minutes
Partial-Sums Algorithm	1.5 days	60 minutes
Subtraction with regrouping – 2 digit numbers	2 days	60 minutes
Subtraction with regrouping – 3 digit numbers	1.5 days	60 minutes
The Trade-First Subtraction Algorithm	1.5 days	60 minutes

Students were assigned daily morning work problems to complete during the 15 minute period at the start of the day until 9am when specials classes were held. The morning work was a review of problems, class discussions, and work from the prior day. Math was taught everyday from approximately 9:45-10:45. Lessons were taught using the assigned mathematic materials for this Central Florida public school. Supplemental materials and lessons were also incorporated. Daily lessons consisted of a review of problems from the morning work, direct instruction or guided instruction focusing on the mathematical content for the day, a guided practice, and an independent practice time. The guided instruction consumed the majority of class time with discussions and sharing of problem solving strategies. The last 10-15 minutes of class was typically allotted for the guided or independent practice time.

In order to allow for the students to become familiar with addition and subtraction that requires regrouping, the idea of Mrs. Smith's candy shop was introduced. Mrs. Smith sells pieces of candy at her shop. When the students are introduced to the idea of her candy shop they are told that she is having problems selling the candy. Some people want to purchase a large amount of candy and Mrs. Smith has to sit and count each piece. Students are asked to brainstorm ideas to help her. The candy shop allowed students to understand a way to group items together. Students discovered for themselves that the candy could be grouped up into candy rolls and boxes to make it easier to sell. This is the beginning of addition with regrouping. As time progressed, students became comfortable with the idea that Mrs. Smith's candy shop now sells not only pieces of candy, but also rolls and boxes. The new problem that Mrs. Smith encounters is that her customers want to purchase pieces of candy, and she only has rolls or boxes. Students are again asked to brainstorm ideas to help her. Now, conversely, the boxes and rolls of candy could be opened up and taken apart to sell different amounts which allowed for students to begin seeing subtraction with regrouping.

According to Balka (1993), base-ten blocks are one of the best manipulatives that can be utilized in the understanding of place value concepts and all the basic operations, including addition and subtraction. To represent the different pieces, rolls, and boxes of candy in the candy shop our class utilized base-ten blocks, as seen in Figure 1. The cubes represented a piece of candy, the longs were representative of the rolls of candy (10 pieces), and the flats were referred to as boxes (10 rolls or 100 pieces).

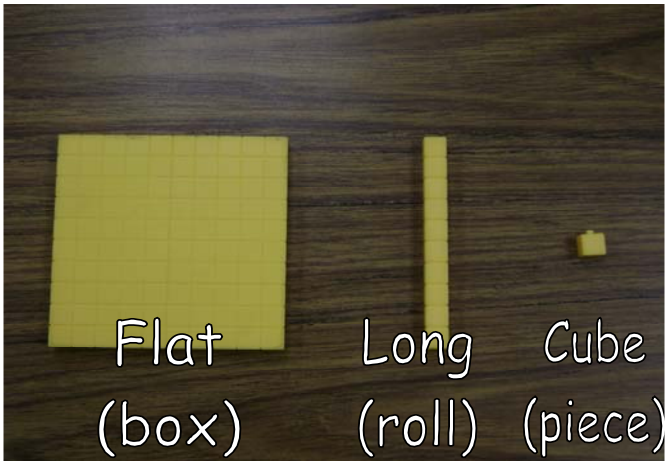

Figure 1: Base-ten blocks

Students were consistently presented with a question that was related to new or unfamiliar content in which they were requested to use their prior knowledge and own ideas to solve it. Students were also consistently asked to explain their thought process and the procedures they used to solve problems. Classroom instruction varied from direct instruction to guided instruction. Most days, depending on the lesson, students utilized manipulative materials to accompany the lesson. Discussions were teacher guided and were meant to facilitate deeper conceptual understanding.

Data Analysis

Pre-test and Post-test

A pre-test (Appendix E) and post-test (Appendix F) were administered to the students to determine a basis for student understanding of the concepts prior to the start of the research and to identify potential changes in academic performance at the conclusion of the unit. The tests were identical and were created by the researcher and approved for use by the university. These tests were checked for face validity by a university professor. It consisted of four addition and four subtraction problems of varying difficulties. The problems included:

- One 2-digit addition problem without regrouping
- One 2-digit addition problem with regrouping in the tens place
- One 3-digit addition problem with regrouping in the one and tens place
- One 3-digit addition problem with regrouping in the one, tens, and hundreds place
- One 2-digit subtraction problem without regrouping
- One 2-digit subtraction problem with regrouping in the ones place
- One 3-digit subtraction problem with regrouping in the ones and tens place
- One 3-digit subtraction problem with regrouping across zeros in the ones and tens place

Students were instructed that they could solve the given problems using any strategy and materials they chose, except the use of a calculator. Manipulative materials were permitted and available during both tests. The pre-test scores were compared to the post-test scores to identify the amount of, if any, improvement the students made. In addition, student work on test questions were analyzed to identify any potential written changes made in the way the students solved the different types of problems.

Video Recordings

Parents and administration permitted videotaping of lessons on the basis that all videos would be destroyed at the conclusion of the research. Video cameras are not a natural part of an elementary classroom. In order to reduce the amount of possible distractions and to allow the students to adjust to this unusual classroom feature, the video camera was set up and displayed in the room for a few weeks before research and recording began.

Selected lessons on multi-digit addition and subtraction were videotaped in order to observe student behaviors in regards to manipulative material usage. Video recordings were also utilized to identify student participation and engagement in lessons and discussions. This type of data provided the researcher with the ability to learn about student's nonverbal behaviors and their location and movement during the course of a lesson (Johnson, 2008). Videotapes were analyzed by recording individual student behaviors throughout each hour-long lesson. Identified participation and engagement characteristics were tallied as well as at-task actions throughout each lesson. See Appendix H for the type of chart used to record these observations. Parts of the video recordings were transcribed in order to clearly show student engagement, participation, and understanding.

Student Work Samples and Teacher Field Notes

Student works samples consisted of practice pages, morning work problems posed to students during their first ten minutes of class time, and exit slips. Practice pages came from the district assigned mathematics workbook and provided multi-digit addition and subtraction practice. Morning work problems were given to the students at the start of each school day and were problems that were discussed and worked on the prior school day. Exit slips were given to the students two to three times weekly and consisted of problems that were discussed and worked on that day in class. These samples served as representations of student products at different time periods to provide insight into the student's work, understanding of concepts, and changes in performances over time (Johnson, 2008). The samples were examined to identify any specific written method of solving the types of problems and their changes over time.

In addition, teacher observation and field notes were taken throughout the course of the study and while viewing video recordings of the class during mathematic lessons. The notes taken throughout the course of the study were written directly on the daily lesson plans. The notes taken while viewing video recordings were made on the participation and engagement chart (Appendix H). These notes paid particular attention to student manipulative choice, student manipulation of the materials, student conversations, and evidence of participation and engagement.

Summary

Data from all sources: pre-tests and post-tests, video recordings, student work samples, and teacher field notes were recorded and triangulated. The data were analyzed to reveal the effects of using manipulatives in my third grade classroom on students' engagement and participation and their academic performance in multi-digit addition and subtraction.

Chapter 4 provides an interpretation of this data. A comprehensive analysis will exhibit how the use of the manipulative materials effected the third graders engagement, participation, and academic performance.

CHAPTER FOUR: DATA ANALYSIS

Introduction

Action research is a process that allows the researcher to study the practices of a real classroom with the goal of better understanding a specific routine, procedure, or instructional strategy more clearly. This action research study was designed to explore how the use of mathematical manipulative materials impact student academics and participation and engagement in the third grade classroom. Recent experiences of my own have allowed me to understand that my personal educational experiences had provided me with the procedural knowledge of basic mathematics. As a third grade teacher, I have observed a large number of students who arrive in my classroom and have only had procedural mathematic experiences in their previous years of schooling. Students have been taught how to solve a problem without the understanding of "why" it is solved that way. The proper use of manipulatives can enhance conceptual understanding of mathematical concepts. This chapter discusses the effects that manipulatives had on third grade student's academic performance and their engagement and participation in mathematics with regards to multi-digit addition and subtraction.

Data collection methods for this study included a pre-test and post-test, student work samples, video recordings, and teacher field notes. The use of multiple data sources allowed for triangulation of the data as seen in Table 3.

The research questions for this study were:

Question #1

What effect do mathematical manipulatives have on my third grade students' engagement and participation?

Question #2

What effect do mathematical manipulatives have on my third grade students' academic performance in multi-digit addition and subtraction?

Table 3: Research Questions and Data Sources

Questions	Data Source 1	Data Source 2	Data Source 3
Academic Performance	Pre-test and Post-test	Student work samples	Teacher field notes
Participation and Engagement	Teacher field notes and observations	Video recordings	

Data Analysis

Academic Performance

Pre-Test Results

The addition and subtraction pre-test was administered to students prior to any instruction in multi-digit addition and subtraction or any use of manipulative materials in my class. Students were directed to solve the problems using any method or materials; however no students chose to use any manipulatives. The pre-test consisted of four addition problems and four subtraction problems. The test contained:

- One 2-digit addition problem without regrouping
- One 2-digit addition problem with regrouping in the tens place
- One 3-digit addition problem with regrouping in the one and tens place

- One 3-digit addition problem with regrouping in the one, tens, and hundreds place
- One 2-digit subtraction problem without regrouping
- One 2-digit subtraction problem with regrouping in the ones place
- One 3-digit subtraction problem with regrouping in the ones and tens place
- One 3-digit subtraction problem with regrouping across zeros in the ones and tens place

On the pre-test, 33% (7) of the students scored a total score of 60% or higher. Figure 2 represents the scores from the pre-test.

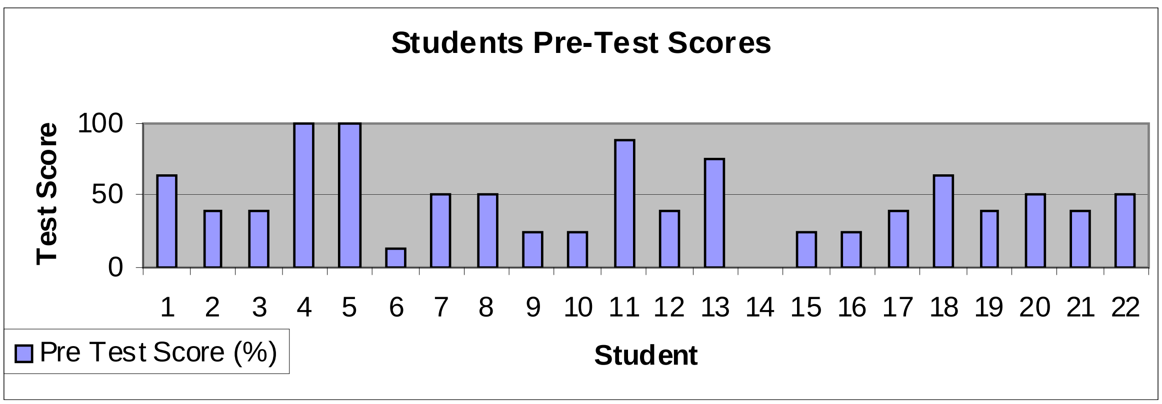

Figure 2: Addition and Subtraction Pre-Test results

Table 4 shows the results of the pre-test with regard to specific questions answered incorrectly. As evidenced by the addition and subtraction pre-test, students were able to solve addition and subtraction problems without regrouping with little or no difficulty. In terms of the two-digit addition problem without regrouping, 95% (20) of the students solved it correctly. The two-digit subtraction problem without regrouping was solved correctly by 86% (18) of the students. The greater number of errors occurred with the larger numbers that involved regrouping, especially when subtracting. When examining the 3-digit addition problem with regrouping in the one place value and the 3-digit subtraction problem with regrouping in the ones and tens place values, 23% (6) and 14% (3) of the students accurately solved these problems, respectively. Subtracting with regrouping across zeros appeared to be a struggle as 14% (3) of the students were able to subtract correctly.

Table 4: Pre-Test Questions answered Incorrectly

Pre-Test Questions		
Question number	**Mathematical Concept**	**Number of Students with Incorrect Answer**
1	2-digit addition without regrouping	1
2	2-digit addition with regrouping in the tens place	2
3	3-digit addition with regrouping in the one and tens place	12
4	3-digit addition with regrouping in the one, tens, and hundreds place	16
5	2-digit subtraction without regrouping	3
6	2-digit subtraction with regrouping in the ones place	15
7	3-digit subtraction with regrouping in the ones and tens place	18
8	3-digit subtraction with regrouping across zeros in the ones and tens place	18

Post-test Results

The addition and subtraction post-test was administered to students after three weeks of instruction on multi-digit addition and subtraction and was identical to the pre-test. Once again, students were directed to solve using any method or materials with the exception of a calculator. Students # 4, # 6, # 13, and # 17 utilized base-ten blocks while completing their post-test and Students # 2 and # 9 used the hundreds board. On the post-test, 62% (13) of the students scored a total score of 60% or higher. Figure 3 represents the scores from the post-test.

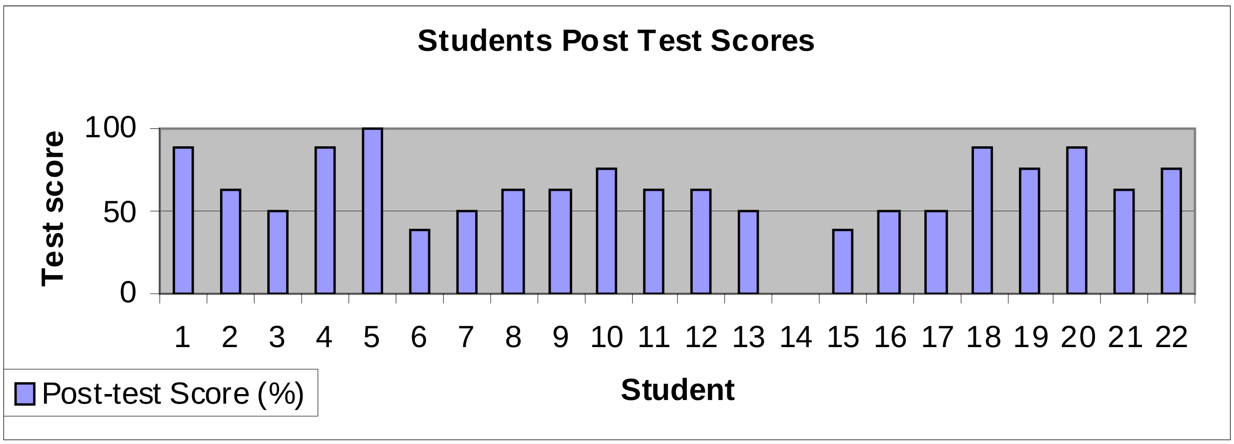

Figure 3: Addition and Subtraction Post-test results

Table 5 shows the results of the post-test with regard to specific questions answered incorrectly. All of the students, 100% (21), were able to answer the addition without regrouping problem correctly and 90% (19) of the students answered the subtraction without regrouping problem correctly. The greater number of errors was found in the addition and subtraction of 3-digit problems with regrouping. When solving the 3-digit addition with regrouping problem, 57% (12) of the students answered it correctly and 38% (8) of the students accurately solved the 3-digit subtraction with regrouping problem. When subtracting a 3-digit number across zeros, only 9.5% (2) of the students were able to attain the correct answer.

Table 5: Post-test Questions answered Incorrectly

Post-test Questions		
Question number	**Mathematical Concept**	**Number of Students with Incorrect Answer**
1	2-digit addition without regrouping	0
2	2-digit addition with regrouping in the tens place	1
3	3-digit addition with regrouping in the one and tens place	3
4	3-digit addition with regrouping in the one, tens, and hundreds place	9
5	2-digit subtraction without regrouping	2
6	2-digit subtraction with regrouping in the ones place	8
7	3-digit subtraction with regrouping in the ones and tens place	13
8	3-digit subtraction with regrouping across zeros in the ones and tens place	19

Pre-test and Post-test Analysis

The purpose of the addition and subtraction pre-test and post-test in this study was to serve as one way to measure changes in student's mathematic academic performance. The pre-test was administered at the beginning of the study. In accordance with the school district mathematics pacing guide, multi-digit addition and subtraction was taught over the course of three weeks. The pacing guides are designed by the school district and are meant to guide teachers to maintain a consistent pace in teaching the curriculum. Multi-digit addition and subtraction instruction was guided by the district assigned textbooks and was supplemented by teacher made games and teacher led discussions and activities. The post-test was administered at the conclusion of the unit to identify any changes in the student's ability to perform academically. Of the students completing the pre-test and the post-test, 16 out of 21 (76%) showed an increased test score. Of the remaining students, 14% (3) of the students showed a decreased test score and 10% (2) of the students maintained the same score. Figure 4 summarizes the students' pre-test and post-test data.

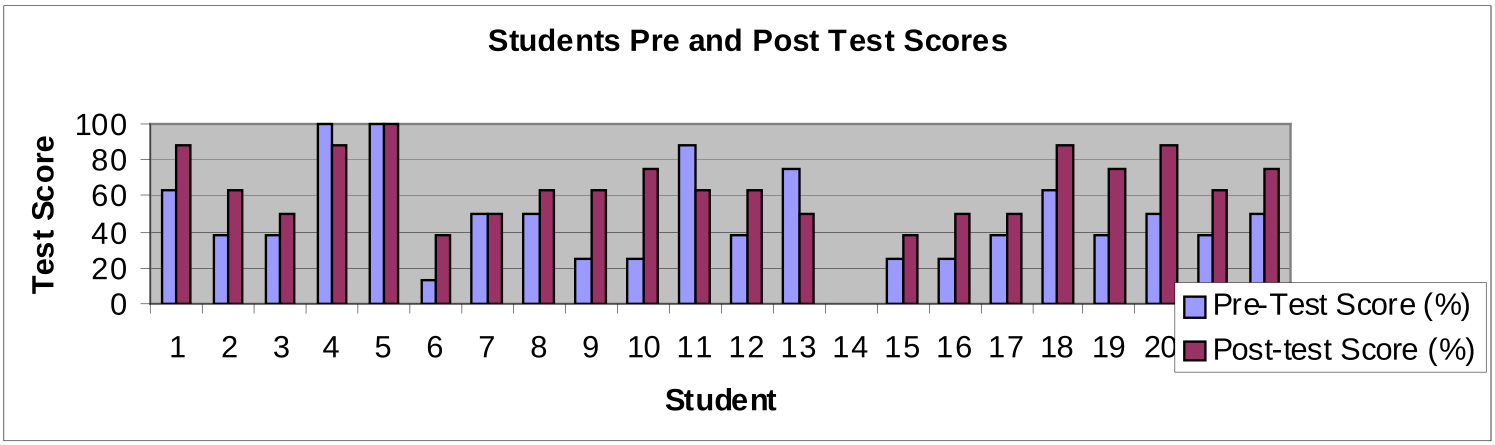

Figure 4: Students Pre-test and Post-test Scores

Further analysis of student tests included identifying observable and written methods the students used to solve the given problems. During the pre-test no students used any manipulative materials. In the post-test, Student # 4, # 6, # 13, and # 17 used the base-ten blocks and Student # 2 and # 9 used the hundreds board to aid them in solving the problems. In order to observe written method changes, student's work on pre-test and post-test problems were defined in one of four ways: 1. showing no work and incorrect answer, 2. showing no work and correct answer, 3. showing work and incorrect answer, and 4. showing work and correct answer. Once examined, it was determined that there were 23 occurrences identified in which students showed no work on their pre-test and subsequently showed their work on the post-test. Of those 23 occurrences, 22 questions were answered incorrectly on the pre-test but were answered correctly on the post-test.

Student Work Samples:

Students completed daily morning work assignments, independent and guided practice in the classroom, homework assignments, and exit slips during this unit all relative to multi-digit addition and subtraction and the math concepts taught in class. Some of this work was collected and organized as student work samples in order to be analyzed as a part of the research study. There was an overwhelming, recurring theme that was observed as a result of this analysis. Many students made no indication of written work on their pre-tests and recorded none of the steps they used to solve the problem. As time progressed, student work typically included more written indicators of regrouping and additionally, a record of the steps they used to solve the problem (Figure 5 and Figure 6).

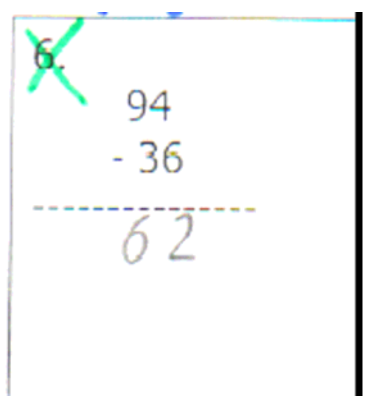

Figure 5: Student # 12 Pre-test

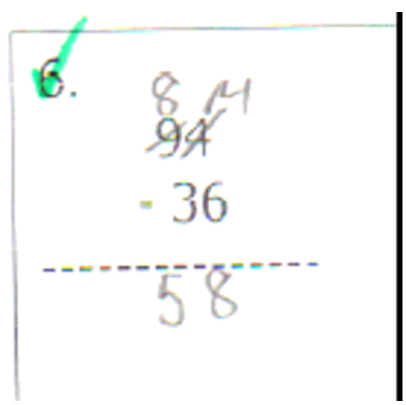

Figure 6: Student # 12 Post-test

Participation and Engagement

Research by Furrer and Skinner (2003) indicated that students who participate in class have shown an active involvement evidenced by them asking questions, offering examples, and making contributions in class discussions. An engaged student refers to active, goal-directed, flexible, constructive, persistent, focused interactions with the social and physical environment (Furrer and Skinner, 2003). It has been shown that students obtain the maximum benefits of learning by active involvement in which true participation and engagement are essential (Petress, 2006).

Participation Surveys

Students were given a written survey to complete in order to gain insight into their idea of what participation in math class means. This survey (Appendix G) consisted of two questions: What is participation in math? and What does it look like if you are participating in a math lesson?

What is participation in math?

The most common responses to this question included the phrases: listening to the teacher, answering questions, and following directions. The following statements represent a sample of the responses:

- It is to do the problem the teacher tells you to do.

- It is when you follow along with the class and stay on task so you can do a good Job in math.
- Doing stuff together working together and while you do stuff together you start to have fun and if someone say to participat [participate] that's like a command.
- Working as a team and listening.
- To follow derections [directions] while the teacher is doing math with us.

The responses from the students show that they typically believed that doing what the teacher asks you to do, when the teacher asks you, how the teacher asks you to do it means that they are actively participating. This is however a partial explanation of the definition of participation used in this research study. Students did provide some responses that referred to participation as teamwork and enjoying the class.

What does it look like if you are participating in a math lesson?

Students were asked to describe the kinds of actions that take place when participation in a math lesson is occurring. The goal was to get an idea of what the students believed it looked like when they are involved in their own definitions of participation. The following statements represent a sample of the response:

- Paying atenchen [attention] to the techer [teacher] and listening.
- You have to look what the teacher is saying and do I so we can get it.
- Sitting quietly while doing math and lisining [listening] to are [our] teacher.
- You are lisening [listening] to what the teacher says and you are doing it.
- You would be answering a lot of questions.

There were an overwhelming number of students who believed that listening to the teacher is something that is done when participating in math. No students made mention of discussions, talking with the teacher or other classmates, or asking questions.

After these surveys were collected and read over, a brief class discussion was held in order to make the students aware that it is appropriate and encouraged for them to ask questions, talk with classmates, offer ideas and suggestions for problem solving, etc. Students were often encouraged to talk with one another about the math.

Teacher Field Notes

Throughout the course of the multi-digit addition and subtraction unit a variety of student participation and engagement actions were observed. Whole group, teacher led discussions were held.

When questions were posed, students routinely raised their hands to provide responses. It was noted when a student answered a question or explained a solution that the remainder of the class paid little attention to what was being said by the student.

Each time a new concept was taught and any manipulative materials were introduced, throughout the school year up to and including the time of research, students were told that they could use any of the materials already introduced. Their attention was directed to the shelves in the classroom in which all the materials were available for use at any time and they were shown where each material is stored.

This unit on multi-digit addition and subtraction introduced students to the use of base-ten blocks. Many of the lessons in this unit involved the use of these materials. Students would often be given a few minutes of free time to explore the materials before delving into the lesson for the day. At the beginning of the unit, students typically used this time to build structures, towers, and to stack the blocks. As time continued and as the familiarity with the materials increased, students were asked to use the blocks in a way other than for play during this free exploration time. At this point, students were observed lining ten cubes next to a long, counting the pieces in their bag, or showing an amount to their neighboring classmates and asking them to count. It was observed that students were comfortable talking with their classmates and holding each other accountable at this point in each lesson. It was noted that one student said to another "You're not supposed to be building with them." The student's response was, "I'm not, I'm making a thousand block!" It was clear that the majority of the students were comfortable with the blocks and able to use them for math related purposes, even when not given specific directions to do so.

According to observations during the course of the lessons, students seemed to exhibit more involvement during lessons when directed or instructed with the use of the base-ten blocks. At points of independent practice students were directed to solve problems using any strategy they wanted, aside from the use of a calculator. About half of the students resorted back to the written regrouping method that they had been introduced to in second grade, while the other half consistently chose to use the base-ten blocks. Morning work assigned each day to the students consisted of a review of the concepts that had been covered in previous days. During this time it was observed that some students left their seat to obtain base-ten blocks to use during their morning work. As the lessons progressed, the use of base-ten blocks to solve problems during independent practice decreased. More students relied on drawing pictures of the blocks or another written technique to solve the problems.

Students seemed to have difficulty transitioning from one math task to another. For example, several students who had not finished working in their math workbooks demonstrated decreased interest and participation in a related discussion or activity. Students were often encouraged to share the alternate strategies they used to solve a problem. Often times when asked to share “different” strategies; many students raised their hands, eager with the opportunity to explain their method. However, there were other times in which few or no students offered to explain how they solved a problem.

Students were reluctant to discuss the math with each other. It appeared that they were more willing to answer questions asked of the teacher rather than talking with their classmates about the topic. It was observed, however, with the use of the manipulatives students were more open to the idea of talking with classmates about the math. A sense of hesitancy was still detected; however the students were talking more.

Video Recordings

In order to obtain a closer look at the student’s participation and engagement in the math lessons, nine students were selected to gather additional data. These students were selected based on their ability levels in mathematics. Three low, medium, and high performing students were chosen for closer observation. These nine students are identified in Table 6.

Table 6: Students identified for video observation

Student #	Gender	Race	Math Performance Level
7	M	H	Low
9	M	H	Low
16	M	W	Low
1	M	H	Med
18	M	W	Med
21	F	H	Med
5	F	W	High
15	M	MIXED	High
20	M	W	High

Videotapes were recorded for the duration of nine lessons of which three will be discussed here. A video from the beginning, midpoint, and end of the unit were selected to be analyzed further. Videotapes were reviewed and a checklist (Appendix H) was used to identify manipulative participation and engagement observed with the selected students. The lessons included students working with and without manipulatives, however the option for their use of these materials was always available. In order to analyze these students' specific behaviors in regards to participation and engagement, a few target behaviors were chosen from the checklist to discuss here.

Beginning Video

This lesson incorporated student's discussion about extended subtraction facts. Students discussed how knowing 12-5 will help them understand how to find 120-50. Students were involved in this discussion, facing the board and consistently raising their hands to answer questions. Students were encouraged to find or share alternate strategies for solving problems. In this lesson students were also introduced to the idea of the candy shop.

Teacher: My friend, Mrs. Smith, has a candy shop where she sells individual pieces of candy. She is, however, having a problem with her shop. Some people come into her shop and want to buy a lot of candy at once and she has to sit and count out the pieces that they want. The problem is, this creates long lines and the people waiting get very impatient. Do you have any ideas of what she can do?

Student # 15: She can ask for help.

Teacher: True, but she needs to find a faster way for her and whoever is helping her. What can she do?

Student # 10: She could get five and put them in a group.

Teacher: Good idea, maybe she can put them in groups of five. Then she can count out the candies by five.

Student # 5: She can get big boxes, like they put candy in so she would not have to count as much.

Teacher: So, she can put the candy in boxes. That way when a person wants to buy a lot, they can get a box instead of counting each piece out. How many should she put in a box?

Student # 15: Thousands

Student # 20: Fifty

Student # 8: Ohhhh, hundreds!

Student # 11: Um, she can put 10 in a bag.

Teacher: Oh, okay…so when somebody wants to buy ten candies they can just get one bag.

Student # 8: Or they can buy a big box!

Teacher: A big box huh? How many could she fit in a big box?

Student # 20: 100!

Teacher: Ok, so what if somebody wanted to buy 200 candies?

Students: They can get two boxes!

Teacher: Do you think that will solve Mrs. Smith's problem and make it easier for her to sell her candy?

Students: Yes!

Teacher: Wow, ok…I'll have to tell her your great ideas!

Students were introduced to base-ten blocks and discussed the appropriate ways to use the manipulatives. They were given a few minutes to explore the materials in order to avoid playing with them at inappropriate times. Students were very involved with the use of these materials. Approximately half the class claimed they had never used base-ten blocks in their previous classes, while the other half stated that they had seen them or used them before. After they had time to explore the manipulatives, students were told that Mrs. Smith liked the idea of packaging the candy into groups of ten and hundreds. She had responded to a fictitious email sent by the teacher and stated that she would group the candy into rolls of ten pieces and boxes of ten rolls. It was decided that the base-ten blocks would be representative of the candy at Mrs. Smith's shop. The longs would represent rolls and the flats would represent boxes. The lesson continued by increasing the student's familiarity with the blocks. Students were asked to represent 22 pieces of candy with their blocks. Students shared the variety of ways that this could be represented (two rolls and two pieces or 22 pieces). An introduction to grouping pieces into rolls or trading the 10 pieces for one roll was addressed. Students practiced this concept.

In general, students were involved and answering questions. Students were eager to use the blocks and learn more about Mrs. Smith's candy shop. Overall, students were lively and the tone of the classroom atmosphere seemed alive and animated. Students continued to appear less attentive when a classmate was talking or explaining their strategies and ideas. Despite the availability of the base-ten blocks some students resorted to counting with their fingers or utilizing the hundreds chart.

Table 7: Student Participation and Engagement- Beginning Video

	Participation		Engagement	
	Volunteers to Answer Question	Answers questions when called on	Sustained Behavioral Involvement	Active Participation (involved in class discussions, etc)
Student				
1			no, however always aware of content discussed	not at all
5	III	I	Yes	Yes
7	II	III	Yes	Yes
9	I		Partially	at times
15	IIIII III	I	Yes	Yes
16		II	Partially	Partially
18		II	Partially	Partially
20	I	I	Yes	Very
21		IIIII	Partially	Partially

Table 7 indicates the student participation and engagement observed from beginning video. Student # 7 exhibited an extremely positive emotional tone. He was very excited and enthusiastic. At some points however, he was observed using the manipulatives in a non-mathematical manner. A few students displayed obvious negative emotional toned behaviors. This included Student # 9 who was in and out of his seat often, Student # 16 who was looking around constantly and at times had his head down, and Student # 1 who kept his head down often. Student # 5 and # 20 interacted with each other on the topic by having their own side conversation about the blocks. Student # 20 asked a question in regards to the base-ten blocks, and Student # 5 provided evidence of conceptual understanding when discussing her solutions and responses to problems.

Midpoint Video

Students worked with the base-ten blocks to add numbers that required regrouping. An addition problem was given to the students and they were directed to solve the problem using any strategy they chose, aside from the use of a calculator. Once given adequate time to work out the problem, students were very willing to share their answers. It was emphasized to the class that the important aspect of our math time was to explain the strategies they used in order to arrive at their solutions. Students shared a variety of methods to solve the given addition problem. Students had no prior addition with regrouping instruction in the classroom this school year. Even after the introduction of the base-ten blocks a few lessons prior, no students chose to use the blocks to solve the given problem.

Teacher: Okay, who would like to share their strategy for solving 52 + 83?

Student # 18: I put 2 + 3.

Teacher: So, you added the numbers in this column first?

Student # 18: Yes.

Teacher: What place value is that?

Student # 18: Ones.

Teacher: Okay, so you added 2 + 3, and what did you get?

Student # 18: Five. Then I added 5 + 8, which is 13 and put it under the tens column. So the answer is 135.

Teacher: Ok, good. Thank you. How many of you solved this problem using the same strategy as Student # 18?

At this time, the majority of the students in the classroom raised their hands indicating that they solved the problem using the standard addition algorithm. Research has shown that this is the method that is most commonly taught in the schools. Table 8 indicates the students' participation and engagement observed from the midpoint video.

Table 8: Student Participation and Engagement – Midpoint Video

	Participation		**Engagement**	
	Volunteers to Answer Question	**Answers questions when called on**	**Sustained Behavioral Involvement**	**Active Participation (involved in class discussions, etc)**
Student				
1	III		Yes	Partially
5	I		sustained listening, not actively participating	No
7	IIII	IIII	Yes, very verbal and involved in discussion	Yes
9	I	I	yes, watching a lot and appearing to be listening	yes, trouble answering questions
15	IIII	I	yes, involved in discussion however not as verbal as usual	Yes
16			No, unfocused and dazed	No
18	IIII	I	yes, very involved and wanting to answer questions often	Yes
20	I	II	Yes	yes, very verbal
21	I		partially involved, not as verbal usual	Partially

Once again, students showed little noticeable signs of listening to the responses shared by fellow students. Some students were physically watching the board as the instructor wrote the information explained by the students. Other students were looking down at their papers and desks, potentially listening or not.

Teacher: Did anyone else solve this problem in another way?

Student # 15: I added the 50 plus 80, and I added them together.

Teacher: Why did you do that?

Student # 15: Cause' I know the five is in the tens place so it's worth 50 and the eight is in the tens place so it's worth 80.

Teacher: Okay, anyone have a question for Student # 15?

No other student raised their hand or indicated they had a question about what this student explained.

Student # 15: So when I add them I got 130. Then I added 2 and 3, and got 5. Then I added 130 plus the 5 and got 135.

Teacher: That works! Anyone else solve it this way?

Students did not indicate that anyone had solved it using the same method as Student # 18. This method is known as the partial-sum algorithm.

Teacher: Anyone solve this problem using another strategy?

Students were unresponsive to this question. At this point the teacher solved the problem using an alternative strategy involving base-ten blocks. Students were exposed to grouping the pieces (ones) together and grouping the rolls together (tens). Once ten rolls were accumulated they could be packaged into a box which represented hundreds. There were 5 pieces and 13 rolls. Therefore the 10 rolls were grouped into one box (hundred), with 3 rolls remaining. The students then identified what was left after the "candy" was repackaged.

Students:	One box, three rolls, and five pieces.
Teacher:	Yup! 135 pieces of candy all together.
Students:	Ooohhh
Student # 20:	Wow, that's cool!

Students expressed interest in the new strategy using the base-ten blocks. The reaction after the teacher shared the blocks to solve the problem was an overwhelmingly positive one, with an obvious excited tone.

During this lesson Student # 7 displayed conceptual understanding in reference to regrouping the one over to the tens place. He was able to provide an adequate explanation. Student # 15 and # 7 interacted with each other when discussing the number of pieces in a roll. Student # 7 felt that there were not ten pieces in a roll and Student # 15 chimed in and told him that there were ten pieces in a roll. When an agreement was not reached after a short period of time, Student # 15 turned to the base-ten blocks to demonstrate and explain that only 10 pieces could fit in a long. This seemed to be enough to satisfy

Student #7. The interaction was welcomed and encouraged by the teacher, and the other classmates turned their heads toward the two student's discussion, which could signify that they were participating by listening. During subsequent addition problems, students appeared to be more focused on the content and strategies shared by their classmates. Students were more attentive to the board where the strategies shared were recorded. Students also volunteered to answer questions more often than previously; in addition they answered questions more frequently when called on. As more problems were posed and solved students overwhelmingly raised their hands to answer questions asked. Students also completed sentences and thoughts for the teacher.

Teacher: When I have 10 rolls, I can package them into….

Students: a box!

As practice problems were assigned and discussed, the teacher emphasized and challenged students to complete problems that were increasingly difficult. Student # 7 responded by shouting "Bring it on!" displaying a clear enthusiasm for the challenge.

Final Video

The focus of this lesson was subtraction with regrouping. Students had already been introduced to this concept and discussed a variety of their strategies, including the use of the base-ten blocks. In this lesson there was time for independent work with the option of discussing with neighboring classmates. This format resulted in less time for students to volunteer to answer questions and solve problems in the whole class setting.

Students spent about half of their math time working at their seats to solve problems in their math journals. Table 9 indicates the student participation and engagement observed from the final video.

Table 9: Student Engagement and Participation – Final Video

	Participation		**Engagement**	
	Volunteers to Answer Question	**Answers questions when called on**	**Sustained Behavioral Involvement**	**Active Participation (involved in class discussions, etc)**
Student				
1	II		yes	Yes
5	II	II	yes	Yes
7	I		yes	Partially
9	I		partially	No
15	IIII		yes	Yes
16			partially	daydreaming, no
18	II	I	yes	Yes
20	II		yes	Yes
21			partially	Partially

At the onset of the lesson student volunteers were asked to come to the board in order to demonstrate their methods for solving assigned subtraction problems. Many students were willing to solve the problems at the board for their classmates.

It was once again observed during this lesson, that students were more willing to show indicators of participation and engagement when the teacher was leading the discussion rather than when students were involved in sharing and discussing strategies. In general, students were much more responsive toward the teacher.

Student # 7 volunteered to solve 90-23 at the board.

Student # 7: First I saw I couldn't take 3 away from zero, so I took from the 9 and it became a 10.

Teacher: How did you make that zero a ten?

Student # 7: I don't know.

Teacher: What do you think you could do to help you?

Student # 7: I can draw the candy.

Teacher: Ok, go ahead. How many rolls and pieces make the 90?

Student # 7: Nine rolls and zero pieces (student drew this on the board)

Teacher: Okay, and what do we need to do?

Student # 7: Take away 23.

Teacher: Can you take away the three pieces from nine rolls and zero pieces?

Student # 7: No.

Teacher: So what can you do?

Student #7: Open a roll (student crosses out a roll and draws the 10 pieces that were unwrapped).

Teacher: How many rolls do you have now?

Student # 7: Eight (student crosses out the nine and changes it to eight).

Teacher: And how many pieces?

Student # 7: 10 (student crosses out the 0 and changes it to 10). Ok, now I do 10-3 and I get 7. Then I do 8-2 and I get 6. So it's 67.

Teacher: Any questions for Student # 7?

One student asked how he figured out the problem. Student # 7 responded correctly and explained what he did to arrive at the solution that he did. When the class was asked who was able to come up with same answer the majority of the students raised their hands. When asked if it was solved with any other strategy or method there were no responses.

One additional problem was reviewed from the assigned morning work. Student # 15 volunteered to come to the board and share his strategy for solving this problem. He explained to the class using the candy boxes, rolls, and pieces. The remainder of the class appeared to be divided. Approximately half the class was looking in the direction of the board indicating they might have been following along with what this student was doing. The other half of the class was focused on their papers and desks. At a point during this student's explanation he appeared to be struggling to explain what he was doing. Immediately after the teacher walked to the front to ask probing and guiding questions almost the entire class focused their attention toward the board. At another point, students were challenged with a subtraction problem.

Teacher: Okay 3rd graders, I am going to the candy shop this weekend to buy 121 pieces of candy.

Students: Whoa, 121! Wow. Yum!

Teacher: I am going to give away 90 of those pieces at a football game tomorrow. Will I have enough candy left to share with this class? How much candy will I have left?

Students were given this subtraction problem (121-90) that would require them to regroup in the hundreds place value. Student # 1, # 5, # 7, # 9, # 15, # 16, # 20, and # 21 automatically picked up their base-ten blocks to figure out the answer to the question. Student # 18 quickly pulled out a sheet of paper to begin writing. He was in fact using his hundreds board to find the number that was 90 spaces (difference) from 121. At this point Student # 20 raised his hand to ask a question, an indication of participation. The majority of the students were on task during this time. Student # 18 shared his method for solving this problem with the hundreds board. Student # 5 volunteered to share a different strategy she used to solve this problem.

Teacher: Great strategies, do I have enough to share with you on Monday?

Students: Yes! You have extra. You have enough for the teachers too! Yea!

At this point students were assigned to work on practice problems independently or with their neighboring classmates if they preferred. Students were instructed to solve the problems using any method or strategy that they preferred with the exception of using a calculator. Students # 1, # 9, and # 15 and some of their classmates were observed utilizing the base-ten blocks during this time. Students were generally on-task and completing the assigned problems. Student # 9 asked a couple questions, exhibiting participation. Student # 16 was observed staring rather than actively working to complete the assigned problems.

Data Interpretation

It is the interpretation of the researcher that the use of manipulative materials in the mathematics classroom had a two-fold effect. According to the analysis of the pre-test and post-test and student work samples, student's academic performance increased with the use of manipulatives during this math unit. Seventy-five percent of the students involved in the research study showed an improvement in their academic performance. In addition, during the course of the study, student participation and engagement were analyzed using video recordings and teacher field notes and observations. The class exhibited on task tendencies, was often paying attention, and involved in class discussions. Students also exhibited many of the characteristics identified with participation and engagement as portrayed on the video checklist (Appendix H). This analysis led to the conclusion that the class had an overall positive emotional tone. The student participation and engagement were impacted positively with the use of math manipulatives. Students were introduced to a new strategy for solving addition and subtraction problems, and based on the data they incorporated these ideas and strategies as an option when solving problems on their own.

Summary

The purpose of this action research study was to examine how the use of manipulatives in my third grade classroom impacted students' experiences. The data collected revealed information regarding student's participation and engagement in the math classroom in relation to the use of math manipulatives. Additionally, information was analyzed relative to student's academic performance and the use of math manipulatives. Two main themes emerged as a result of this data. The first theme implicated that student’s academic performance increased throughout the unit on multi-digit addition and subtraction with the use of math manipulatives. The second theme that became apparent was that there was a positive effect on student engagement and participation with the involvement of math manipulatives.

In the following chapter the findings and conclusions will be discussed. Possible implications, limitations, and recommendations for future research will also be addressed.

CHAPTER FIVE: CONCLUSION

Introduction

The goal of this research study was to identify the effects of using mathematic manipulative materials on third grade student's academic performance, participation, and engagement in multi-digit addition and subtraction. Throughout the duration of this study data were collected to aid in the determination of these effects. Data were gathered from a variety of sources to determine effects on academic performance. These sources included student work samples, teacher made pre-tests and post-tests, and teacher field notes. Data were also collected to identify effects on third grade student's participation and engagement using video recordings and teacher field notes and observations.

Once the data were collected it was analyzed, providing an in depth examination of the effects on the third grade students. The analysis provided insight into the relationship between mathematic manipulative materials and student participation and engagement in the mathematics class. In addition, information was acquired as to whether or not the use of manipulatives had any effect on academic performance. This chapter discusses the conclusions made as a result of the data analysis, limitations regarding the research study, and recommendations for future research.

Conclusions

This action research study was carried out in my third grade classroom by incorporating the use of mathematical manipulative materials in a unit on multi-digit addition and subtraction. The use of a pre-test and a post-test and analyses of student work samples provided insight into the student's academic performance. Teacher observations, field notes, and the use of video recordings were analyzed to determine student's engagement and participation in class and the effects on them by the use of the manipulatives.

The purpose of this study was to investigate two questions.

Question #1

What effect do mathematical manipulatives have on my third grade students' engagement and participation?

Students were given opportunities to manipulate and explore the base-ten blocks prior to the formal instruction of each lesson. At the onset of the study, exploration using the base-ten blocks involved the students manipulating the blocks, building towers with them, and creating shapes and designs. As the math unit and the study progressed, student use and exploration of the base-ten blocks at the beginning of each lesson began to incorporate a more mathematical way of thinking. They counted their base-ten blocks, counted an amount and quizzed their classmates, and made groups of tens and hundreds. This displayed a more clear understanding and knowledge of the possible uses of the base-ten blocks. Students increased their use of the blocks for math purposes. In addition, at the start of the math unit students were not very responsive to working with the other students or discussing the mathematic content with their classmates. The students asked and answered more questions and volunteered more often in a teacher led discussion. As the unit continued there was an obvious increase in talking, asking and answering of questions, and sharing of information and ideas among the students when involved in the use of manipulative materials. Video recordings revealed students specific involvement in the math class. The observations of nine specific students over the course of three video recordings (beginning of the unit, midpoint, and end of the unit) showed that two of the students increased their observable participation and engagement characteristics. At the onset of the research study Student # 1 and Student # 18 did not demonstrate sustained behavioral involvement or active participation. However, as time progressed their involvement and active participation increased. Four of the students, Student # 7, # 15, # 20, and # 21, maintained steady involvement and active participation. They did not demonstrate any increases or decreases in their participation, but were partially or fully engaged throughout the course of the research study. Student # 16 struggled to stay engaged and actively participate. He was consistently partially involved or not involved at all. The remaining students (Students # 5 and # 9) behavior appeared to alternate between active involvement and non-participation. There were no steady increases or decreases in these students' observable participation and engagement.

The data collected from the endpoint video recording showed that students volunteered less often to answer questions and never answered questions when called upon. It is important to note that this lesson was recorded and analyzed at the end of this unit and differed from the typical lessons that were taught. Students spent a short time reviewing morning work problems and were assigned problems to practice. There were not the same opportunities for a whole class discussion as in other lessons; however students were encouraged to work with their classmates if they preferred to do so. This allowed the researcher to observe student interactions and preferences for working with manipulative materials.

Turner and Patrick (2004) believe that participation in lessons can facilitate learning and the students' motivation to learn can play a role in whether the student chooses to participate or not. Student comments and enthusiasm in this study displayed a clear motivation to be involved in the classroom activities. "Wow, that's cool!" and "Bring it on!" clearly demonstrated the students' motivation which in turn impacted their participation.

When taking into account all of the information collected, analyzed, and described here it is clear that students' engagement and participation in the math class typically showed an increase as the mathematic manipulatives were utilized in lessons. Students talked more, asked questions, and volunteered to answer questions consistently. The use of manipulative materials may have been favored more by some students than others; however there was an overall positive effect on engagement and participation consistent with their use. The use of manipulative materials in this unit on multi-digit addition and subtraction had the potential to increase student participation and engagement in class.

Question #2

> What effect do mathematical manipulatives have on my third grade students' academic performance in multi-digit addition and subtraction?

In order to identify any effects on the students' academic performance a pre-test was given at the onset of the research. This test illustrated that students clearly lacked understanding and proficiency in multi-digit addition and subtraction. Most students also used little or no written methods to solve the problems and none of the students used any manipulative materials.

Analyzing the students work showed similar characteristics. To begin with, students typically did not use any written method to add or subtract, especially in problems that required regrouping. As time progressed, the students work samples began to show more written record of their thoughts and processes used to solve the problems. A few students drew the base-ten blocks to help them solve the given problem.

The administration of the post-test showed significant differences. Some of the students utilized mathematic manipulative materials on the post-test. Of those students, half of them showed an increase in test scores, while the other half showed a decrease in their scores. Other students applied written strategies and records of the processes they used to solve the problems. There were 23 occurrences identified in which students showed no work on their pre-test and subsequently showed their work on the post-test. Of those 23 occurrences, 22 questions were answered incorrectly on the pre-test but were answered correctly on the post-test. Seventy-five percent of the students involved in both the pre-test and the post-test showed an increased test score.

Petress (2006) claimed that student learning is best facilitated when students actively participate in the learning process. The students who appeared to be most actively involved, both exhibiting characteristics of participation and engagement as gauged by the video recordings all made increases in their test scores, with the exception of Student #7 whose score remained the same.

The use of manipulative materials in this research study was not the only factor that could have raised student test scores and increased procedural and conceptual understanding. As suggested by Isaacs and Carroll (1999), student learning should begin with the child's natural thinking and require that they compose their own strategies for problems that they are unfamiliar with. This was a component of instruction in this research study. Students were, at times, given an unfamiliar or new problem and asked to find a way to solve it. As a result, a wide variety of strategies were shared, explored, and discussed including, however not limited to, the use of manipulatives. The exposure to different strategies for solving multi-digit addition and subtraction problems and the conceptual reasons for regrouping that were discovered and demonstrated had the potential for causing student test scores to increase as they did.

Based on the data collected and analyzed, the use of mathematic manipulatives had the potential to increase students' academic performance; however was not the only reason for the increase found in this study.

Limitations

The results found in this study cannot be generalized to all other classroom populations. There are limitations in this study that must be noted. The population of students involved in this study was not large enough to make conclusive assumptions. These third graders were assigned to the researchers' classroom by the administration and reflect the overall make up of the school population. Students are individuals with a wide variety of learning styles and preferences. In addition, the parental support of some students in the class may vary greatly from other students involved in this research study. The involvement of parents at home can greatly affect the students' performance in the classroom. Teachers are individuals as well. The teaching styles, preferences, presentation of concepts and materials, and interactions with students can vary from one teacher to the next. The knowledge of mathematic manipulative materials that the teacher possesses may also be a great variance. These are all limitations that could have affected the outcome of this study.

Recommendations

The results of this study have potential. Students seemed more engaged and willing to participate in class when they were able to use manipulative materials. After conducting this action research study, I have found a need for further research in the area of academic performance, engagement, and participation with the use of mathematic manipulatives.

There are two recommendations I would make based on the results of this study. First, as a result of the short length of this unit, regulated by pacing guides set forth by the district, the research questions could have been better researched over a longer period of time. I feel that the topic was too narrow, and researching these questions beyond a unit on multi-digit addition and subtraction could have provided more insight into how manipulatives truly have an effect on student academic performance, engagement, and participation. Secondly, it would also have been helpful to conduct student interviews to gain more insight into how and why students used or did not use manipulatives the way that they did. Doing so may provide more depth as to what the students were thinking or feeling about the use of these materials.

Discussion

Vinson (2001) declares that too many students in the United States have only a moderate level of procedural knowledge of mathematics, and an even lower level of conceptual knowledge. As a teacher with a strong mathematics background, this information is alarming and very concerning. Through a literature review and my graduate school experiences, I have learned that this low level of conceptual knowledge can be directly correlated to traditional teaching in the classroom.

I believe that every student should be given their greatest opportunity to learn. It is because of this belief that I was often looking for different and new ways to help my students reach their full potential and gain the greatest benefits while enrolled in my classroom. Using manipulatives, to me, was always one way to work toward accomplishing this goal. This research study has afforded me the opportunity to look at one aspect of my teaching in great depth. I have been able to look closely into the effects of using mathematical manipulatives in the third grade classroom.

Using the mathematical manipulative materials throughout this math unit proved to be a great motivator for the third graders. The obvious increase in participation and engagement characteristics were phenomenal. Students were often raising their hands to answer questions and appeared to exhibit more at-task tendencies. The process of completing this study has forced me to consciously move toward a more constructivist approach in my classroom. Students were encouraged to create and share their own strategies for solving problems more often than being told how to do it. As a result, students were given more than one strategy to choose from when doing math. It was because of this that I was unable to determine whether the manipulatives played a role in the increased test scores and gains in academic performance, or if the involvement and participation in a more student centered classroom was a factor. Regardless, my students showed progress and improvement with which I was delighted.

The information gained from this study will be carried with me as a part of my personal teaching philosophies. I plan to continue to use mathematical manipulative materials regularly in my own classroom and to work to provide more constructivist aspects in my teaching. I feel that this process of reflecting on my own teaching has taught me the importance of evaluating the methods used in the classroom, and so I also plan to continuously reflect on my role as a teacher and how it impacts my students. This process has helped me to learn more about myself as a teacher and about how students learn, and I look forward to continuing to learn as my career continues.

APPENDIX A: IRB APPROVAL

University of Central Florida

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901, 407-882-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Notice of Expedited Initial Review and Approval

From : **UCF Institutional Review Board**
FWA00000351, Exp. 5/07/10, IRB00001138

To : **Caryn Ross**

Date : **August 24, 2007**

IRB Number: **SBE-07-05135**

Study Title: **The impact of manipulatives in multi-digit addition and subtraction on student participation, engagement, and academic performance.**

Dear Researcher:

Your research protocol noted above was approved by **expedited** review by the UCF IRB Vice-chair on 8/23/2007. **The expiration date is 8/22/2008.** Your study was determined to be minimal risk for human subjects and expeditable per federal regulations, 45 CFR 46.110. The categories for which this study qualifies as expeditable research are as follows:

6. Collection of data from voice, video, digital, or image recordings made for research purposes.

7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

The IRB has approved a **consent procedure which requires participants to sign consent forms.** Use of the approved, stamped consent document(s) is required. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Subjects or their representatives must receive a copy of the consent form(s).

All data, which may include signed consent form documents, must be retained in a locked file cabinet for a minimum of three years past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

To continue this research beyond the expiration date, a Continuing Review Form must be submitted 2 – 4 weeks prior to the expiration date. Advise the IRB if you receive a subpoena for the release of this information, or if a breach of confidentiality occurs. Also report any unanticipated problems or serious adverse events (within 5 working days). Do not make changes to the protocol methodology or consent form before obtaining IRB approval. Changes can be submitted for IRB review using the Addendum/Modification Request Form. An Addendum/Modification Request Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at http://iris.research.ucf.edu .

Failure to provide a continuing review report could lead to study suspension, a loss of funding and/or publication possibilities, or reporting of noncompliance to sponsors or funding agencies. The IRB maintains the authority under 45 CFR 46.110(e) to observe or have a third party observe the consent process and the research.

On behalf of Tracy Dietz, Ph.D., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 08/24/2007 09:51:06 AM EDT

Joanne Muratori

APPENDIX B: PRINCIPAL APPROVAL

Informed Consent to Conduct Research

June 27, 2007

To Whom It May Concern:

This coming school year Caryn Ross, a third grade teacher at ,
will be conducting an action research project in her classroom on the use of manipulative materials in multi-digit addition and subtraction and the affects on student participation, engagement, and academic performance. I am writing this letter to give my consent to allow her to conduct the research with her class for the 2007-2008 school year.

During Ms. Ross' study she will be video/audio taping whole class and small group discussions that take place during the math block (M, T, Th, F 1:00-2:00 and W 11:45-12:15, 12:45-1:15). She will also be conducting student surveys and interviews sporadically. Student work samples will be collected and analyzed as well.

We do not anticipate any risks to the students during this study. Any connection between the students and the data she will collect will be destroyed upon completion of the study, and students names will not be used anywhere in the thesis. She will be obtaining informed consent from her students' parents/guardians allowing their children to participate in the study and to be video/audio taped, as well as assent from the students that they understand the purpose of the study and the expectations of them during the process. Participation in the study is not mandatory, and parents will have direct contact with her faculty advisor and Ms. Ross at all times. Extra credit will not be given for participation and student math grades will not be affected in any way.

Sincerely,

APPENDIX C: PARENTAL CONSENT FORM

Informed Consent to Participate in Research Study

August 2007

Dear Parent or Guardian,

My name is Caryn Ross and I am excited to be your child's teacher this year! I have spent time this summer planning for the coming school year, and I am confident that your child will have a positive learning experience in my class.

In addition to my responsibilities as your child's teacher, I am also a graduate student in K-8 Math and Science Education at the University of Central Florida. I am currently planning a research project for my Master's thesis that will take place within my classroom from August until sometime in December. The goal of my research is to study the effects of using math manipulative materials (including base ten blocks, hundreds board, counters, snap cubes, etc.) in multi-digit addition and subtraction. I am interested in studying the use of these materials and how they influence your child's participation, engagement, and academic performance.

With your permission, I will video/audio tape your child taking part in whole class and small group activities and math lessons, although audio and video tapes will be destroyed at the completion of the project. I will also collect samples of your child's math work. Participation in this study is completely voluntary. If you choose to not allow your child to participate in the study, their classroom experience will not differ. I will still require them to complete all necessary math coursework and to participate in the lessons; however no data will be collected based on their work. Compensation such as extra credit will not be provided, and participation will not affect your student's grades in any way.

Your child's identity will be kept confidential during this study. The purpose of this study is to analyze my teaching practices, not assess your student's mathematical ability. I do not anticipate any risks to your student during the course of the study, only the potential benefit of identifying effective teaching and learning strategies for elementary mathematics. Upon completion of the project, any connection between your student and the data collected will be destroyed.

If you have any questions regarding this study, you may contact me at anytime at . You may also contact my UCF faculty advisor, Dr. Gina Gresham, at (407)823-3550. You may withdraw consent at any time. Questions or concerns about participant's rights may be directed to the UCF IRB Office of Research and Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32806. The hours of operation are Monday through Friday, 8:00 a.m. – 5:00 p.m. The phone number is (407)823-2901.

Thank you so much for your help in this process. I look forward to working with you and your child this school year!

Sincerely,
Caryn Ross

I have read the procedure described above and understand what is being asked of my child as a participant of this research study. I voluntarily agree to allow my child to participate in the study and to be video/audio taped during whole class and small group session. I have received a copy of this form.

____

Name of child (Printed)

☐ I give consent for my child to participate in the study.

☐ I give consent for my child to be video/audio-taped during class time.

☐ I would like more information about this study.

Name of Parent/Guardian (Printed)	Name of Researcher (Printed)
Name of Parent/Guardian (Signed)	Name of Researcher (Signed)
Date	Date

Page 1 of 3

Informed Consent to Participate in Research Study

Consentimiento Informativo para Partifipar en Estudio Investigato

agosto 2007

Estimados Padre o Guardian,

Mi nombre es Caryn Ross y me llena de alegría ser la profesora de su niño este año. He pasado este verano planeando el próximo año escolar, y estoy muy confiada que su niño tendrá una experiencia de aprendizaje positiva en mi clase.

En adición a mis responsabilidades como profesora de su niño, también soy una estudiante graduada en educación en las Matemáticas y Ciencia K-8 de la Universidad de la Florida Central. Estoy planeando actualmente un proyecto de investigación para la Tesis de mi Maestría que se llevará a cabo dentro de mi salón de clases a partir de agosto hasta diciembre. La meta de esta investigación es estudiar los efectos de las matemáticas usando materiales manipulativos en la suma y la resta con dígitos múltiples en actividades y materiales donde el estudiante estará mas activo en el salón de clase. Estoy interesada en estudiar el uso de estos materiales y como estos pueden influenciar en la participación, el aprovechamiento, y el funcionamiento académico de su niño.

Con su permiso, yo estaré grabando un vídeo con audio de su niño hablando y participando en el salón de clase, aunque los videos y grabaciones seran destruidas al final de este projecto. También haré actividades de grupos pequeños y pequeñas lecciones de Matemáticas. Recogeré muestras del trabajo de Matemáticas de su niño para utilizarlas en mi estudio. La participación en este estudio es totalmente voluntaria. Si usted decide que su niño no participe en este estudio, la experiencia en el salón de clase no será diferente. Se requerirá que su niño participe y haga el trabajo escolar necesario de matemática pero la información de su trabajo escolar no será colectada pare el estudio. Crédito adicional no será proporcionado, y la participación no afectará las notas del estudiante de ninguna manera.

La identidad de su niño será mantenida confidencial durante este estudio. El propósito de este estudio es analizar mis prácticas de enseñanza solamente, no para determinar la capacidad Matemática de su niño. No anticipo ningún riesgo al estudiante durante este estudio, solamente el beneficio potencial de identificar las estrategias de enseñanza y aprendizaje para las Matemáticas Elementales. Cuando se termine el estudio todo material y datos recogidos serán destruídos.

Si usted tiene cualquier pregunta con respecto a este estudio, puede comunicarse en cualquier momento al Usted también puede comunicarse a la Universidad Centra de la Florida (UCF) con mi Consejera de la Facultad, la Dr. Gina Gresham, al (407) 823-3550. Usted puede retirar su consentimiento en cualquier momento. Cualquier pregunta o duda sobre el derecho del participante se pueden dirigir a UCF IRB Office of Research and Commercialization, 12201 Research Parkway, Oficina 501, Orlando, FL 32806. Las horas de operación son de Lunes a Viernes de 8: 00 AM - 5:00 P.M. El número de teléfono es (407) 823-2901.

Muchas gracias por su ayuda para poder realizar este estudio. Espero poder trabajar con usted y su niño!

Sinceramente,
Caryn Ross

He leído el procedimiento descrito arriba y entiendo que se está preguntando que si mi niño puede participar en este estudio de investigación. Estoy de acuerdo voluntariamente en dejar que mi niño participe en el estudio y sea grabado en Video/Audio durante el período de clase y en las sesiónes pequeñas de grupo. He recibido una copia de esta carta.

____

Nombre del niño (Letra de Molde)

____Doy consentimiento para que mi niño participe en el estudio.

____Doy consentimiento para que mi niño sea grabado en Video/Audio durante el periodo de clase y cuando lo entreviste.

___Quisiera más información sobre este estudio.

Nombre del padre/del guardián (Letra de Molde)	Nombre del investigador (Letra de Molde)
Nombre del padre/del guardián (Firma)	Nombre del investigador (Firma)
Fecha	Fecha

APPENDIX D: STUDENT ASSENT LETTER

Student Assent to Participate in Research Study

August 20, 2007

Dear Student,

Welcome to my class! I am very excited about being your teacher this school year. Just like you go to school during the day, I go to school in the evening. I am a student at UCF. I am working on a project this year that will help me to be a better teacher. During this project, I would like to video and audiotape our class to learn more about our math lessons.

You do not have to participate in this study if you don't want to. Remember I am learning about how I teach and you don't get a grade for it.

I look forward to getting to know you this school year. Thank you!

Sincerely,

Ms. Ross

By signing below, I am saying that it is okay to be video and audio recorded by my teacher.

By signing, I am saying that I am willing and would like to participate in this study.

______________________________ ____________________

Student Name Date

APPENDIX E: PRE-TEST

Name:_________________

Addition and Subtraction Pre-test

Solve the following problems using any method or materials.

1. 72 +24 ---------------	2. 76 +43 ---------------
3. 439 +163 ---------------	4. 874 +358 ---------------

Solve the following problems using any method or materials.

5.

    84
  - 72

6.

    94
  - 36

5.

    276
  - 187

5.

    900
  - 432

APPENDIX F: POST-TEST

Name:_________________

Addition and Subtraction Post-test

Solve the following problems using any method or materials.

1. 72 +24 ---------------	2. 76 +43 ---------------
3. 439 +163 ---------------	4. 874 +358 ---------------

Solve the following problems using any method or materials.

5.
```
  84
- 72
---------------
```

6.
```
  94
- 36
---------------
```

5.
```
  276
- 187
---------------
```

5.
```
  900
- 432
---------------
```

APPENDIX G: PARTICIPATION SURVEY

Name:_________________

Number:_______________

What is **participation** in math?

____

____

____

____

____

____

____

____

____

What does it look like if you are **participating** in a math lesson? (What kind of things are you doing?)

____

____

____

____

____

____

____

____

____

APPENDIX H: VIDEO RECORDING ENGAGEMENT AND PARTICIPATION OBSERVATION CHECKLIST

Engagement Behaviors

	Positive Emotional Tone (seems happy, excited, etc.)	Negative Emotional Tone (seems upset, bored, etc.)	Sustained Behavioral Involvement	Initiation of action	Active participation (involved in class discussions, etc)
STUDENT					

Participation Behaviors

	Spontaneous Use of Manipulatives	Appropriate Use of Manipulatives	Asks Questions	Provides Evidence of Concept Understanding	Classmate Interaction on topic	Volunteers to Answer Questions	Answers Questions when called on	Demonstrate at board	NONVERBAL Watching/ Listening/Thinking
STUDENT									

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