The Effect of Participation in Active Learning Strategies on the Mathematics Fact Fluency Achievement of First Grade Students

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Table of Contents

List of Tables

Abstract

The purpose of this study was to examine the impact of active learning strategies on mathematics fact fluency achievement of at risk first graders in a Title I school in Anne Arundel County. The participants included 18 first grade students who participated in active mathematics learning strategies. Data was also collected from another first-grade class in the same school that did not participate in active mathematics learning strategies. The measurement tool used to assess mathematics fact fluency was a math fact computation test created by Anne Arundel County Public Schools. The null hypothesis that there will be no fact fluency achievement difference in students who engage in active learning strategies compared to those who do not was supported. Both groups improved their math fact performance however there were no statistically significant gains.

CHAPTER I

INTRODUCTION

Mathematics instruction in first grade focuses on building a strong foundation of the essential skills and concepts students' need to be successful in math. These skills and concepts include developing number sense, understanding and applying strategies for problem solving, and strategies for adding and subtracting. In first grade students learn to use a variety of manipulatives, models, and strategies to add and subtract. Examples include using concrete objects, number lines, part-part-whole models, counting on, and counting back, and application of the commutative property. The Common Core Standard suggests students add and subtract within 20, demonstrating fluency within ten, using strategies such as counting on, making a ten, decomposing a number leading to a ten, using the relationship between addition and subtraction, and creating equivalent but easier or known sums by creating the known equivalent. Prior to entering first grade, kindergarten students are exposed to the concepts of addition and subtraction and strategies for adding and subtracting. The first-grade standard related to fluency builds on the kindergarten standard which suggests kindergartners fluently add and subtract within five. A significant component of math instruction in first grade focuses on fact fluency. Due to the high level of importance, fact fluency is taught throughout the entire school year and mastery of the standard is expected at the end of first grade. In Anne Arundel County Public Schools, the expectation is that a minimum of ten minutes daily is devoted to math fact fluency instruction and practice for every student.

Just as reading fluency increases comprehension, math fact fluency supports problem solving and more complex math concepts. Fact fluency is defined as "the efficient, appropriate, and flexible application of single-digit calculation skills and an essential aspect of mathematical

proficiency (Kling, 2011, p.82)". Fact fluency instruction is systematic and progressive. Godfrey and Stone, (2013) identify three developmental stages of math fact fluency. The first is counting strategies, which include using concrete objects or verbal counting to solve facts. The second is reasoning strategies. Students in this stage use known facts and relationships to solve new facts. The third stage of math fact fluency is mastery which is the point where students have reached automaticity in basic math facts. Therefore, fluency instruction and practice are most effective when it is differentiated and developmentally appropriate.

Developing math fact fluency in first grade is important because it supports student achievement in other areas of mathematics. For example, mastery of math facts increases students' computation accuracy, aids in problem solving, and sets students up to be successful with higher level math concepts. "Addition and subtraction facts are the baseline for future work with fractions, decimals, ration, and proportion, and much more (O'Connell & SanGiovanni, 2011, p.xiii)". Research has showed that mastering math facts produces "stronger estimation skills, more accurate complex computation, and improved problem solving (Riccomini, Stocker, & Morano, 2017)". Developing math fact fluency positively impacts students' success and helps them become proficient mathematicians. Consequently, the absence or lack of fact fluency can negatively impact student achievement in mathematics. Students who have not yet developed fact fluency are more likely to have difficulty solving more complex computation and tend to be less efficient when applying problem solving skills and strategies. Students who are not fluent spend majority of their time trying to solve basic computation, and often struggle when presented more rigorous math concepts and skills. In addition, as math tasks increase in complexity, they become more "time consuming, and often stressful, for students who must stop to figure out each math fact along the way, which often disrupts the flow of the math procedure (O'Connell &

SanGiovanni, 2011, p.3)". The more math facts students master, then the brain can focus on more rigorous math tasks. Math fact fluency is an essential foundation for student success in mathematics.

As previously discussed, fact fluency instruction is systematic and progressive. Fluency assessments can be used to determine which of the three developmental stages of fluency a student is currently in as well as to distinguish between known and unknown facts. Progress monitoring allows students to celebrate their success and aids teachers in making instructional decisions and goals. Effective instruction and intervention focuses on conceptual understanding of the facts rather than memorization and timed drills. Specifically, this includes the application of strategies and using efficient and effective ways to relate known facts to unknown facts. When recalling math facts, students are more successful when they can relate understanding to the task. Once students have a conceptual understanding of the strategies, then students can participate in meaningful and engaging practice. Opportunities for student practice include the use of manipulatives and models, hands on games and activities, real world problems and applications, and technology and computer-based programs.

In this study, the researcher used a variety of active engagement strategies to teach the conceptual understanding and provide meaningful and engaging fact practice. A variety of children's literature was used to introduce the concept and strategies related to the fact set being taught. Then, active learning and engagement opportunities for practice include subitizing, students acting out real world problems, and individual and partner games. Each intervention was implemented throughout the math instructional block daily.

Statement of the Problem

The purpose of this study is to examine the impact of active learning strategies on math fact fluency achievement of at risk first graders in a Title I school in Anne Arundel County.

Hypothesis

The null hypothesis is there will be no fact fluency achievement difference in students who engage in active learning strategies compared to those who do not.

Operational Definitions

- Fact Fluency Achievement – Fluency achievement was measured by administering a pre and post fluency assessment. The assessments were scored based on the number of math facts answered correctly and whether the student was in the counting stage, reasoning stage, or fluent stage.
- Active Learning Strategies- Daily intervention such as number sense routines (subitizing), acting out real world problems, games, and hands on practice with concrete objects.

CHAPTER II

REVIEW OF THE LITERATURE

This literature review examines the research and literature on computational math fact fluency and best instructional practices. Effective strategies and practices for increasing students' fact fluency are explored. First, the importance of mastering the basic math facts in first grade is examined. Next, the relationship between low socioeconomic students and low levels of achievement in mathematics is explored. Then, active learning and brain- based research as it applies to best instructional practices is presented. Finally, the application of active learning to increase student's computational math fact fluency is addressed.

Defining Math Fact Fluency

National Common Core Curriculum standards in math need students to develop math fluency. Standard 1.OA.C. 6 states that students must add and subtract within 20, demonstrating fluency for addition and subtraction within 10. This standard includes using strategies such as counting on, making ten, decomposing a number leading to a ten, using the relationship between addition and subtraction, and creating equivalent but easier or known sums. It is critical that first graders master this standard to prepare them for more complex math skills in the future. Kling defines fact fluency as "the efficient, appropriate, and flexible application of single-digit calculation skills and an essential aspect of mathematical proficiency (2011, p.82)". Rather than rote memorization methods, fact fluency is developmental. Godfrey and Stone, (2013) label three developmental stages of math fact fluency. The first is counting strategies, which include using concrete objects or verbal counting to solve facts. The second is reasoning strategies. In this stage, students use known facts and relationships to solve new facts. The third stage of math fact fluency is mastery which is the point where students have reached

automaticity in basic math facts. Mastery is critical because computational fluency is related to achievement in higher level mathematical concepts. Research has showed that mastering math facts produces "stronger estimation skills, more accurate complex computation, and improved problem solving (Riccomini et al., 2017)". Achieving mastery allows students to apply math facts to more advanced mathematical tasks.

At-Risk Students and Low Achievement in Mathematics

Research shows that children from low socioeconomic backgrounds demonstrate low levels of math achievement. For instance, many students come to first grade with no logico-mathematical concept of number, which makes it difficult for them to develop math fact fluency. Number sense is critical for learning other skills and concepts in first grade math. Knowledge of number sense helps students understand numbers, number relationships, and problem solve. Number sense is the foundation for success in mathematics. Typically, parents and family first teach number sense at home through games, literature, and experiences. Early number sense skills "appear to have a socioeconomic correlation, with students from more affluent families displaying more highly developed number sense at an earlier age than students from disadvantaged backgrounds (Durham, 2012, p.41)". Students from low-socioeconomic backgrounds come to first grade lacking many of the foundational math concepts and skills that their middle-class peers have already developed. "The logico-mathematical foundation of number that low-performing, low-socioeconomic first graders have developed is at the level of most middle-class three and four-year old (Kamii, Rummelsburg, & Kari, 2005, p.42)".

Based on Piaget's theory, logico-mathematical knowledge consists of mental relationships such as classification, seriation, number, special relationships, and temporal relationships. All of which are necessary for higher order relationships such as addition and subtraction. Before

children can develop logico-mathematical knowledge, they must have knowledge of objects which Piaget refers to as physical knowledge. Physical knowledge games are beneficial for low-performing, low-socioeconomic first graders who have not fully developed their logico-mathematical foundation. A study of low performing first graders in Title I schools showed that children who received constructivist-based instruction, including physical knowledge activities, scored much higher on the posttest compared to those who received traditional math instruction (Kamii et al., 2005). Kamii et al., (2005) suggest that the constructivist group scored higher on the post-test because of the logico-mathematical foundation the children built while taking part in the constructivist physical knowledge activities. In addition, study results also demonstrate higher levels of logical reasoning through word problems. In conclusion, low socioeconomic children are at risk for poor logico-mathematical knowledge resulting in math fact disfluency. To help support these children, teachers can incorporate physical knowledge activities into math instruction to help build their mathematical thinking.

Active Learning: Rationale and Benefits

Brain research shows strong connections between movement and the enhancement of learning. An essential part in learning is engagement. Physical, emotional, social, and cognitive elements comprise engagement as exemplified in "active learning". Active engagement enhances learning because it includes "The joint functioning of motivation, movement, conceptual knowledge, cognitive strategies, and social interactions in learning activities (Stevens-Smith, 2016, p.720)". Research shows that when instruction includes active engagement students are more likely to process and keep information and likely to show higher levels of achievement. Brain research shows clear mind-body connections. Studies show that actively engaged children learn best when moving, because movement allows for stimulation

enhancing children's ability to learn unfamiliar information. Stevens-Smith (2016) explained that researchers found that the brain uses the same part to process movement as it does to process learning. Physically engaged children develop neurological foundations that aid with problem solving, language development, creativity, and abstract thought. Active learning allows the brain to grow and function. In addition, studies found that physical activity has a positive impact on memory, concentration, and classroom behavior. Hall (2007) explains that integrating physical activity into academic content areas helps increase student achievement because it gives greater access to the curriculum. Although daily instructional schedules are very precise, it is imperative to incorporate active learning into math instruction. By actively engaging the students, they can concentrate better and gain and process unfamiliar information.

Recommended Best Instructional Practices and Strategies

Traditional computational fluency instruction consists of rote memorization of isolated facts typically with flash cards and timed drills or tests. However, recent research shows that successful computational fluency instruction should focus on developing and applying mathematical strategies and using efficient and effective ways to relate known facts to unknown facts. The goal of fact fluency is shifting to help students develop good mathematical strategies and thinking rather than quick memorization. To aid students in developing efficient and effective mathematical strategies, they must learn to compose and decompose numbers. The ability to compose and decompose numbers is essential in developing computational skills. Computational math fluency should be based upon the students' development and application of strategies. Kling (2011) suggests teaching students the commutative property to help decrease the amount of facts they must learn. For example, if a student can understand and apply the commutative property, then a student that knows 2+3=5 also knows 3+2=5. Other strategies

emphasized are understanding that adding and subtracting zero does not change the value, adding and subtracting one and two by connecting it to the counting sequence, using doubles and near doubles, and the strategy of making ten. Offering opportunities for students to discuss and share their mathematical thinking helps students to develop and understand strategies which will help them become fluent. The opportunity for students to discuss and share their thinking helps students make sense of the strategies and keep the concepts, which increases their fact fluency. Kling (2011) explains a variety of instructional opportunities for students to engage in meaningful and motivating practice. An efficient and effective warm up activity is using quick images. During this activity, the teacher quickly flashes a dot pattern or a pattern on a ten frame. The goal is for students to be able to subitize, or quickly recognize the dot pattern. Using quick images builds visualization and pattern recognition skills. Also, this activity helps students understand that numbers can be decomposed in several ways. As students see different representations of a number, they begin to learn addition combinations.

Computational math fluency is critical because it is the foundation for higher level mathematical skills. Student practice should be purposeful, include opportunities for movement, and target the students' needs. Aligned with curriculum standards, purposeful practice addresses the student's weaknesses. To differentiate facts and practice, a pre-assessment can be administered to determine the students' current level. Riccomini et al., (2017) highlight how progress monitoring can guide instruction and help improve student success. The goal of progress monitoring is to observe continual, gradual progress. Teachers can assess and monitor progress in a variety of ways other than timed tests. Additional assessments include interviews, observations, and journals (Kling & Bay-Williams, 2014). Computational math fluency is just

one piece of mathematical proficiency. Math fact fluency is imperative because it helps students build conceptual understanding, procedural knowledge, and problem-solving skills.

Using Active Learning in Math Instruction to Increase Students' Math Fact Fluency

As teachers are seeking new effective instructional approaches to increase students' computational fact fluency, teachers can integrate active engagement and movement into math instruction. There are benefits to incorporating active engagement and movement into instruction and "Research shows that the integration of movement can impact students' performance, elevate test scores, and also improve classroom behavior (Hall, 2007, p.124)". Once students have learned the strategies and have developed the conceptual understanding, students can engage in activities that foster movement to practice and develop fluency. Movement can be incorporated through acting out real-world problems, hands-on games and activities, and music and dance. Pairing math facts with music can help students develop fluency as "Studies show a link between music and increased learning when academic content is paired with music (Wilmes, Harrington, Kohler-Evans & Sumpter, 2008, p.663)". Once students have a conceptual understanding of the strategies, teachers can give opportunities for students to actively engage in practice.

Another way to incorporate meaningful and motivating practice into instruction is using games. Kling (2011) explains two hands-on games which allow students to practice fact fluency. The first is Tens Go Fish, played just like the traditional game, only using combinations of ten. Another game that promotes engagement and active learning is Turn Over Ten. This game is played like the traditional memory game Concentration, with the cards displaying combinations of ten. One may easily change both Tens Go Fish and Turn Over Ten to any fact set or strategy being taught and practiced. Teachers have used these games and found them to be effective. One

teacher reported that she "used the games often and they became the most requested games in her first-grade classroom (Kling, 2011, p. 87)". Students can also engage in hands-on partner games with their peers to practice addition and subtraction facts. "Classrooms incorporating communication by cooperative learning and real-world applications are crucial to student success and achievement (Wilmes et al., 2008, p.662)". As students engage in hands-on practice, teachers can chunk the fact sets to be practiced. Once a student masters a fact set, then they can move on to the next set. "Because the working memory has a capacity for immediate recall, students can remember more successfully when information is separated into chunks (Willis, 2007, p.315)". Engaging students in repeated interactive, hands on activities that integrate movement gives multiple representations of the facts. A study was conducted among first graders to improve their math fact fluency with a variety of intervention strategies. The twenty-one first graders were put into three distinct groups. The study found that "the groups that had additional interventions beyond a computer-based intervention showed approximately 10% more growth than the control group (Truffer, 2017, p. 16)". Willis (2007) explains that the more ways the material is learned and practiced, the more connections are made in the brain. Wilmes et al., (2008) describes the most effective instructional model for increasing students' computational math fact fluency as one in which students are given opportunities to engage in repeated hands on, collaborative, activities with their peers and multiple opportunities for movement. Incorporating active learning strategies can increase student achievement since "The more muscle groups and fibers recruited during physical activities integrated with subject matter concepts, the stronger and more concrete learning (Hall, 2007, p.124)".

Summary

The literature reviewed defined math fact fluency and the role it plays in developing proficiency in mathematics. Factors and relationships between low socioeconomic students and low math achievement were found as well as procedures for offering supports for these students. A rationale and benefits of active learning and other brain-based teaching strategies was explained. Effective instructional practices and strategies were explored as well as a variety of ways to assess and monitor students' progress. Finally, the literature review addresses how teachers can integrate active learning into math instruction to increase student's math fact fluency.

CHAPTER III

METHODS

Design

The purpose of this study was to examine the impact of active learning strategies on math fact fluency achievement of at risk first graders in a Title I school in Anne Arundel County. A quasi-experimental design was used. The subjects included two first grade classes from the same school. One first grade class received math instruction which included active learning strategies to improve math fact fluency. The other first grade class used Fastt Math, a computer-based math program for practicing math fact fluency. The students used the computer-based program for ten minutes each day.

Participants

The participants attended a Title I elementary school located in northern Anne Arundel County. In addition, the school was named a STEM in Society school and provides enhanced educational opportunities for the students. The school population consisted of 695 students from diverse backgrounds. The school's demographics include 26% Hispanic, 5% Asian, 28% African America, 34% White, and 7% Multi-Racial. 78% of the student population received free or reduced school meals. 15% of the student population had limited English proficiency and received ESOL services. 10% of the students received special education services.

The first-grade class that engaged in active learning strategies during math fact instruction was composed of 18 students; eight males and ten females. Diverse ethnic groups included 17% Multi-Racial, 44% White, 28% African American, and 11% Hispanic. Fourteen students in the class (78%) received free and reduced meal services. Three students in the class

received special education services and one student was an English Language Learner who received ESOL services.

The first-grade class that received the Fastt Math intervention compared to active learning consisted of 17 students including nine females and eight males. This is also a very diverse class. Ethnic groups consist of 59% Hispanic, 12% White, 6% Pacific Islander, 6% Multi-Racial, and 18% African American. Fifteen students in the class (88%) receive free and reduced meal services. Two students in the class receive special education services and six students are English Language Learners and received ESOL services.

Instruments

In this study, the researcher administered a pre and post assessment to both a class that received active learning strategies and another class that received Fastt Math intervention. The paper-based assessment was created by Anne Arundel County Public Schools and intended to be used with first graders to assess math computation and math fact fluency. The assessment consisted of 40 math computation problems. Twenty problems involved addition, and twenty involved subtraction. The assessment included a variety of math facts all with a sum or difference within ten, including fact sets plus and minus one, plus and minus two, plus and minus zero, doubles, and, making ten. The pre and post assessment was administered in small groups of four to five students. The assessment was not timed, and the students were not provided any manipulatives to assist them in completing the problems. Although the assessment was not timed, the researcher did make note of students that were slow and laborious.

Procedures

To begin, baseline data was collected by administering the pre-assessment to the 18 first grade students in the class. The pre-assessment was administered in small groups of 4-5 students so that the researcher was able to observe the participants and record anecdotal notes on their behaviors and strategies. Based on the pre-assessment results and the researcher's anecdotal notes, two groups were formed. The first group consisted of students that scored below 50% and relied solely on counting strategies such as using their fingers or drawing a picture to solve the math facts. The second group consisted of students who scored above 50% and demonstrated some reasoning strategies and relationships to solve unknown facts. Examples of reasoning strategies include, knowledge of the commutative property, fact family relationships, and the relationship between addition and subtraction facts. Grouping the students based on their pre-assessment data and developmental stages helped the researcher target student needs and placed an intentional focus on active learning strategies that would help students become fluent.

Active learning strategies were used with both groups of students to target specific skills and concepts. In this study, math was taught five days a week for one hour. Each math lesson began with a ten-minute number sense routine. This consisted of showing the students dot images and having the students practice subtilizing. As the researcher quickly flashed a dot pattern, the students were asked to find how many dots. These images were strategically selected to help students increase their number sense skills and understand concepts such as counting on, the commutative property, and understanding relationships and patterns among math facts. The next twenty-five minutes of math instruction included the students acting out word problems which incorporated the math facts that the students were learning. Finally, during the last twenty-five minutes of the math lesson, the students participated in hands-on

independent and partner games where they were able to practice using strategies and reasoning to help them achieve math fact fluency. Examples of hands-on games included domino addition, addition and subtraction memory/concentration, math fact B.I.N.G.O, triangle fact cards for practicing fact families, math fact tic-tac-toe, connect four, and, beanbag addition and subtraction. All the math fact games included addition and subtraction math facts where the sum or difference was within ten. To progress monitor the students, the research administered a fact check at the end of each week. The active learning intervention was implemented for five weeks, and then a post-assessment was administered.

The first-grade class that did not receive the active learning intervention was also administered the same pre-assessment by the researcher. This class used FASTT Math, a computer-based program designed to help students master math facts, three times a week for 20 minutes. The Fastt Math program used an initial fluency assessment to collect baseline data for each student. The baseline data showed facts that the student already mastered and facts that the student has yet to learn. Then, the program provided instructional lessons with scaffolds that targeted the students' needs. The program monitored student progress and adjusted instruction as students mastered facts. After explicit instruction, the students independently practiced through their choice of twelve different games designed to develop mastery. The program allowed students to view their progress and rewarded students as they mastered fact sets. The researcher was able to monitor the students' progress through the program. After five weeks of using the Fastt Math program, the students were administered the post-assessment.

CHAPTER IV

RESULTS

The purpose of this study was to examine the impact of active learning strategies on math fact fluency achievement of at risk first graders in a Title I school in Anne Arundel County.

A pretest and posttest mathematics test for first grade students participating and not participating in active learning strategies were analyzed using a t test for independent subjects. The results are presented in Table 1.

Table 1

Pre and Post Test Results for Students Participating in Active Mathematics Learning Strategies.

Test	Active Learning Strategies	Average	N	Standard Deviation	t	Significance
Pretest	Yes	61.7	18	34.55	1.38	0.19
	No	77.0	17	30.90		
Posttest	Yes	72.8	18	28.91	0.90	0.38
	No	81.9	16	30.44		

The null hypothesis that there will be no fact fluency achievement difference in students who engage in active learning strategies compared to those who do not is supported.

CHAPTER V

DISCUSSION

The null hypothesis was supported in this study. The students that did not receive active learning strategies in mathematics scored higher on the pre and post test than the group that received active learning strategies in mathematics. However, there were no statistically significant gains. The group that received active learning strategies in mathematics had statistically significant gains from the pre and posttest ($t= 3.21$, $p= 0.0005$).

Implications of Results

The results from this study show that there were no statistically significant differences between the two subject groups. Both subject groups showed improvement on the post test. The group that participated in active learning strategies in math scored higher on the posttest compared to the pretest. Although the group that participated in active learning strategies showed more growth on the posttest, the group that did not receive active learning strategies in math scored higher on the pretest. Overall, there were no statistically significant gains in the two groups.

Threats to Validity

There were a few factors that may have threatened the validity of the results of the study. First, the two subject groups were non-randomly assigned, therefore the two groups might have differed in important but unknown ways. This includes student learning styles and behaviors as well as students' academic performance and capabilities. Second, the group that did not participate in active learning strategies in mathematics scored higher on the pretest than the group that did receive active learning strategies in mathematics. Therefore, this group did not have the opportunity to make significant gains. The group that did not participate in active

learning strategies experienced mortality as one student moved. Although the two groups were very similar in size throughout the study, this did alter the number the number of students that completed the posttest. Lastly, this study involved two different teachers. Factors such as teaching styles, instructional goals and objectives, and instructional decisions could have influenced the results of the study.

Connections to Previous Studies/ Existing Literature

The results of this study are like those of other researchers. A study of low performing first graders in Title I schools showed that children who received constructivist-based instruction, including physical knowledge activities, scored much higher on the posttest compared to those who received traditional math instruction (Kamii et al.,2005). The students that participated in the active learning strategies experienced repeated hands on practice through games and activities that promoted collaboration and social interaction. Wilmes et al., (2008) describes the most effective instructional model for increasing students' computational math fact fluency as one in which students are given opportunities to engage in repeated hands on, collaborative, activities with their peers and multiple opportunities for movement. The post test results showed that the students that participated in active learning strategies scored higher than they did on the pretest prior to receiving the active learning strategies. Research shows that when instruction includes active engagement students are more likely to process and keep information and likely to show higher levels of achievement.

Implications for Future Research

If more research were to be conducted on effective ways to increase students' math fact fluency, it could be beneficial to incorporate more than one intervention. For instance, in addition to participating in active learning strategies, students could also utilize computer-based math fact programs and participate in additional small group instruction with a teacher. Also, additional research could be conducted by having math fact fluency instruction be infused in other classes such as music, gym, and art classes and incorporating active learning strategies during those times. This instruction could be in addition to the math instruction taking place in the general education classroom which would increase exposure and opportunities for practice. Lastly, in the future, it would be beneficial to extend the intervention for a longer period to see more significant gains.

Conclusions and Summary

This study examined the impact of active learning strategies on math fact fluency achievement of at risk first grade students. Two first grade classes in the same school participated in the study. One class participated in active learning strategies during math fact instruction and the other class did not. In summary, the data shows that students in both groups increased their math fact knowledge over the course of the study. In conclusion, participating in active learning strategies during math fact instruction was not significant.

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